REPORTS

OF THE

SLEEPING SICKNESS COMMISSION

OF THE

ROYAL SOCIETY.

No. VIII.

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By Lieutenant A. C. H. Gray, R.A.M.C., and the Late Lieutenant F. M. G. Tulloch, R.A.M.C. (Sleeping Sickness Commission).

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INTRODUCTION.

After the departure of Captain E. D. W. Greig for England on November 15, 1904, the work of the Commission at Entebbe was carried on by Lieutenant A. C. H. Gray, R.A.M.C., until he was joined on January 10, 1905, by Lieutenant F. M. G. Tulloch, R.A.M.C. The strength of the Commission was subsequently increased by the addition, for a limited period, of Professor E. A. Minchin, of University College, who reached Entebbe on April 3, 1905. The work of this observer on the relation of the Tsetse fly and *Trypanosoma gambiense*, together with some further notes by us on the trypanosomes found in freshly caught tsetse flies, will form the subject of a separate Report. Professor Minchin, having completed the task assigned to him, left for England on December 6, 1905, while Messrs. Gray and Tulloch remained to continue the work of investigation. It was arranged early in March, 1906, that Lieutenant Gray should return to England to collaborate with Professor Minchin in his Report. Unfortunately it was found on the 12th of that month that Lieutenant Tulloch was suffering from fever and his blood was found to contain *Trypanosoma gambiense*. How this disastrous result was brought about is uncertain. It may have been that he infected himself on March 2 in performing a *post-mortem* examination on a rat which died with its blood swarming with this trypanosome, but as he had suffered on at least two previous occasions from indefinite fever, it is more probable that he had been infected for some considerable time. This brought the work of the two officers to a tragical conclusion. Lieutenant Tulloch was invalided home, and he and Lieutenant Gray left Entebbe for England on April 3 last.

At this stage of the investigation it is not possible to bring forward many altogether new facts in relation to sleeping sickness. Certain lines of work were suggested to the members of the Commission by the Tropical Diseases Committee of the Royal Society in April last which they have tried to follow out. Additional evidence is now brought forward in favour of the correctness of the conclusions arrived at in the last Report, together with a few fresh facts, which may be summarized as follows :—

(1.) That trypanosomes are constantly present in the lymphatic glands of early and late cases of trypanosome infection, and can be found there on any day of the disease.

(2.) That the subsequent incidence of sleeping sickness is much higher among natives in whom gland-enlargement has been previously noted than among those in whom no such condition has been found.

(3.) That trypanosomes are not present in the cerebro-spinal fluid of very early cases of trypanosome infection, but that these parasites can always be found there in late stages of the disease.

(4.) That sleeping sickness is the last stage of trypanosome infection and is always fatal. The after-history of cases noted some three years ago by previous members of this Commission has been carefully followed out and only one man now certainly remains alive.

(5.) That trypanosomes can nearly always be found on post-mortem examination of cases of sleeping sickness, provided that such examination be made within a few hours of death.

(6.) That the treatment of trypanosome infection with drugs does not hold out much hope of success even in early cases.

(7.) That chimpanzees are readily infected with the trypanosome of sleeping sickness, that gland enlargement soon follows in them, and that parasites are numerous in their enlarged glands. The one experimental chimpanzee in the hands of the members of the Commission closely resembled a man in the early stage of trypanosome infection, but unfortunately he soon died from captivity.

(8.) That there is but one human trypanosome in Uganda and that it is identical with *Trypanosoma gambiense.*

(9.) That native dogs in an area of sleeping sickness have been found by the Commission to be infected with a trypanosome, and that this trypanosome is most probably identical with the trypanosome of sleeping sickness.

(10.) That the drug treatment of artificially infected animals with almost poisonous doses has proved of little value.

(11.) That the trypanosome of the "Jinja cattle disease," if not *Trypanosoma Brucei*, is a very closely allied species; and that drug-treatment in the case of this trypanosome has proved successful with one monkey only, inoculated with this disease.

Sleeping sickness in Uganda seems to be surely spreading still further afield. The outbreak at Bugungu on Lake Albert, referred to in the previous Report, has assumed more serious proportions. It would seem from information sent to the Commission by Dr. Ashton Bond that the Toro district has also become infected. *Glossina palpalis* has been brought to Messrs. Gray and Tulloch from such a southerly point as the shore of Lake Tanganyika.

An extensive scheme for accurately mapping out the areas infested with Tsetse fly and with sleeping sickness in Uganda is now on foot under the direction of Dr. A. Hodges.

The present members of the Commission wish, in the first place, to thank Colonel D. Bruce, C.B., F.R.S., for his constant encouragement and advice in the work, and for his kindness in correcting the proofs of this Report; Professor E. A. Minchin for his numerous and valuable suggestions on the subjects of investigation, and Captain E. D. W. Greig, I.M.S., who has been in constant communication with the Commission since his departure. Their sincere thanks are also due to Colonel Hayes-Sadler, C.B., His Majesty's Commissioner and Consul-General Uganda, for his invariable kindness in providing facilities for the work; to Mr. George Wilson, C.B., His Majesty's Acting Commissioner for Uganda, for his helpfulness in procuring a chimpanzee for experiment and for the many other ways in which he has shown his interest in the progress of the researches; to Lieut.-Col. J. Will, P.M.O.; to Dr. R. U. Moffat, C.M.G., for valuable assistance and advice; to several other helpers who have kindly provided us with blood films from various wild animals; and to the Bishops and Missionaries of the various churches who have greatly furthered the investigation by sending cases of sleeping sickness, and by observing natives under their control.*

I.—*The lymphatic glands in Sleeping Sickness.—Gland punctures.*

The earliest descriptions of sleeping sickness mention enlargement of the lymphatic glands as a prominent and early feature of the disease. The natives of Uganda look on this gland enlargement as an early sign of infection, and have even advocated the removal of the enlarged glands as a means of cure. Slight enlargement of the superficial lymphatic glands becomes apparent probably within one or two months of infection and persists all through the course of the disease. It is often, however, less marked in those late cases, where life will last only a few weeks longer, than in the earlier stages where the other symptoms are but slight. All the glands of the body are more or less involved and the superficial glands of the neck and axilla show this enlargement quite early in the disease. The typical enlarged gland is smooth, separate, moveable and soft, about five-eighths by three-eighths of an inch in size, and with the consistency of a ripe damson, giving the impression, on palpation, that hard pressure would cause it to burst. This gland enlargement is rarely visible to the eye alone, except in emaciated individuals.

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* Since these lines were written Lieutenant Tulloch has succumbed to his illness (20th June, 1906). A career of great promise has thus been sadly and prematurely closed. The Tropical Diseases Committee of the Royal Society takes this opportunity of expressing its great sorrow at the loss of one to whom it owes a tribute of sincere gratitude for the enthusiasm and ability which he devoted to the difficult and dangerous task entrusted to him. A martyr to science, he passed away before the last records of his labours had been given to the world. These records of work carried on jointly by him and Lieutenant Gray have been finally arranged and revised by the latter and are given in the present Report.—[Sec. R.S.]

In our examination of persons supposed to be infected with Trypanosomes we have regularly employed the method of gland puncture first described in the "Proceedings of the Royal Society" for May 1904 (Greig & Gray). We have used this method alike on natives of Africa, on Indians and on Europeans, and have found it uniformly successful and practically painless.

When dealing with the timid native of Africa, several small points are worth attending to and help towards a successful examination. The posterior cervical glands are by far the most suitable for puncture, because they are superficial, easily handled, and practically always enlarged, while at the same time the operation cannot be seen by the patient. The needle of the hypodermic syringe used should be as fine and as sharp as possible, and the piston of the syringe should give good suction when drawn out of the barrel. The instrument should be carefully kept out of sight of the patient. A suitable enlarged gland is then found and picked up between the finger and thumb, the patient is then warned that he will only feel a sharp prick, and the needle (with syringe attached) is at once sharply pushed through the skin and well into the middle of the gland substance. The point of the hypodermic needle is now gently moved about in the gland substance and an assistant asked to slowly draw out the piston of the syringe and to keep it drawn out. The barrel of the syringe is then detached from the needle, leaving the needle alone sticking into the gland. The needle with its contained drop of juice is then carefully removed from the gland; the barrel of the syringe is again attached and the drop of juice is at once blown out into and mixed with a minute drop of normal citrate solution kept ready to hand on a glass slide.

If the needle and syringe are both withdrawn together from the gland, the drop of gland-juice is usually found immediately to run up into the barrel of the syringe instead of staying in the needle, and can hardly be got out again for examination; but if the simple precaution here noted is taken no such difficulty arises. Another small precaution, which we have found useful in very hot weather, is to have the hypodermic needle (not barrel of syringe) full of normal citrate solution at the time of puncture, thus preventing any possibility of the drop of gland-juice drying up before it is blown out on to the slide for examination. By this method of gland-puncture we have over and over again at once found trypanosomes in persons whose blood and cerebro-spinal fluid had proved negative after a prolonged search.

We wish to lay special stress on the fact that trypanosomes are practically always present in the lymphatic glands of an infected person, and can be found there on any day and at any stage of the disease. It is true that in some cases the gland-juice shows more parasites at one time than at another, but trypanosomes can nearly always be found in a fresh specimen of the juice without any difficulty. For confirmation of this statement, we would refer the reader to the table of gland, blood and spinal fluid examinations on page 11.

Within 24 hours of death we have often noticed that living trypanosomes could not be found in the gland-juice, and it has been quite exceptional to find parasites in the glands at a *post-mortem* examination. We consider that this fact is due to a terminal bacterial invasion causing the death of the trypanosomes.

In June, 1904, 64 apparently healthy natives who lived on Sesse Island were examined by the Rev. H. T. C. Weatherhead. Each individual was carefully examined for gland enlargement, and full particulars for future identification were recorded. It was found at this time that 30 out of these 64 men showed a definite enlargement of their cervical lymphatic glands.

In July, 1905, just a year later, Mr. Weatherhead again visited this island and examined the same individuals, or such of them as were still alive. He found that nine of these 64 men had died of or were in the last stages of sleeping sickness, and that all except one of these nine men had been noted by him as showing marked gland-enlargement the year previously although otherwise seeming perfectly healthy. These results show then that of a given number of natives who all show enlargement of their lymphatic glands but seem otherwise healthy, one-third will be found to have died from sleeping sickness within a year from such examination. The very fact of enlargement of the glands of the neck, presenting the characters mentioned above, may thus be taken to be of itself almost sufficient proof of trypanosome infection if it occurs in inhabitants of a sleeping sickness area.

II.—*The Cerebro-spinal Fluid in Sleeping Sickness. An account of* 143 *lumbar punctures performed at early and late stages of this disease.*

Since November 1904, 40 patients have been admitted to our hospital as either early or late cases of sleeping sickness. 32 of these patients are dead, all but one of them having undoubtedly died from sleeping sickness as proved by the clinical course of the disease and by *post-mortem* examination.* Trypanosomes have been found in the cerebro-spinal fluid of 30 out of these 31 fatal cases of sleeping sickness at some time or other before death. The one case in which trypanosomes were not found was only examined a few hours before death.

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* The one case (Rehani, No. 36) died from sarcoma of the cervical glands with secondary deposits in the internal organs. Trypanosomes were also present in the blood of this man; but a microscopical examination of his brain after death showed no small-celled infiltration so typical of sleeping sickness, nor were trypanosomes found in his cerebro-spinal fluid during life, so that no doubt in his case the trypanosome infection was quite recent.

We have omitted from the following list any lumbar punctures performed by us in which the resulting spinal fluid was found to be contaminated with blood to any appreciable extent, if trypanosomes were also found to be present in a blood-film taken at the time of the operation. All these cases showed marked lethargy which deepened into coma as death approached. In nearly every case the temperature was sub-normal for several days before death.

On these 31 fatal cases of sleeping sickness, 104 lumbar punctures have been performed at varying periods before death, with the following results :—

TABLE I.

The examination of the cerebro-spinal fluid of 31 fatal cases of Sleeping Sickness for *Trypanosoma gambiense.*	Trypanosomes present in	Trypanosomes absent in
Of 43 examinations made more than 100 days before death.	18	25
Of 61 examinations made within 100 days of death.	58	

In these last three fatal cases in which trypanosomes were not found, the lumbar punctures were performed within 24 hours of death.

On the remaining 14 cases who are still alive, 39 lumbar punctures have been performed, with the following results :—

TABLE II.

The examination of the cerebro-spinal fluid of 14 cases of Sleeping Sickness, who are still alive, for *Trypanosoma gambiense.*	Trypanosomes present in	Trypanosomes absent in
Of 6 examinations made on five very early cases.	0	6
Of 25 examinations made on four intermediate cases.	15	10
Of 8 examinations made on five late cases ...	8	0

These observations entirely corroborate the original statement made by Col. Bruce, that "*the cerebro-spinal fluid of every case of sleeping sickness contains trypanosomes during life.*"

We have had the opportunity of examining the cerebro-spinal fluid in a few early cases wherein no symptoms had been detected other than occasional fever and the presence of trypanosomes in their blood and lymphatic glands. In these cases the cerebro-spinal fluid has been found by us to be perfectly normal ; containing no trypanosomes, and with only the slightest trace of cellular deposit after centrifuging. We may say then, from the observations we have had an opportunity of making, that *the cerebro-spinal fluid of early cases of trypanosome infection does not contain trypanosomes.*

When we come to consider the cases between these two extremes, that is to say, the cases between 100 and 300 days of death, of 30 lumbar punctures actually performed by us, 22 have been positive and eight negative.

We give the following table, which shows the date and the number of days before death of any given lumbar puncture, and also the state of the blood, as shown by a large blood film, and gland juice at the time of the operation. In every case 20 cubic centimetres of cerebro-spinal fluid were drawn off, centrifuged at once for five minutes, and the whole deposit was examined fresh. As above stated, in early cases of trypanosome infection we have always found that the white cell-elements are exceedingly scanty, appearing as only a slight film at the bottom of the test tube after centrifuging. We have likewise observed the presence of trypanosomes in the cerebro-spinal fluid to be accompanied by some increase in the number of white cells, and that as death draws near the number of white cells increases. We have noted in several cases within a day or two of death that trypanosomes could not be found in the cerebro-spinal fluid which on former examinations had constantly shown parasites, but that the cellular deposit was as large or even larger than before. Probably the presence of large numbers of diplococci may be responsible for the disappearance of the trypanosomes.

TABLE III.

Showing the Result of Examinations of the Cerebro-spinal fluid, Blood and Gland-juice of 46 cases of Sleeping Sickness for Trypanosoma gambiense :—

Name.	Date.	Number of days before death.	Trypanosomes		Cerebro-spinal fluid.	
			In Blood.	In Glands.	Trypanosomes.	Leucocytes.
Timitao ...	12.9.04	74	—	...	+	Slight incr.
M. 25 yrs.	17.11.04	8	—	+	+	Incr.
(1)	25.11.04	Autopsy	—	—	—	”
Abyabu ...	15.8.04	133	+	+	+	Slight incr.
M. 20 yrs.	23.9.04	94	+	+	+	”
(2)	21.11.04	35	—	+	+	Incr.
	20.12.04	6	—	+	+	Large incr.
	26.12.04	Autopsy	—	—	+	”
Badingo ...	3.10.04	86	—	+	+	Incr.
M. 20 yrs.	25.11.04	33	—	+	+	”
(3)	26.12.04	2	+	+	+	Large incr.
	28.12.04	Autopsy	—	—	+	

Name.	Date.	Number of days before death.	Trypanosomes		Cerebro-spinal fluid.	
			In Blood.	In Glands.	Trypanosomes.	Leucocytes.
Zenabu ... F. 19 yrs. (4)	11.1.05	81	—	+	+	Slight incr.
	1.3.05	32	—	+	+	"
	30.3.05	3	+	+	+	Incr.
	2.4.05	Autopsy	+	+	+	"
Kaparaga ... M. 28 yrs. (5)	4.1.05	25	—	+	+	"
	27.1.05	2	—	+	+	"
	29.1.05	Autopsy	—	—	—	"
Suddwaka ... M. 22 yrs. (6)	21.1.05	52	—	+	+	"
	6.3.05	8	—	+	+	Large incr.
	14.3.05	Autopsy	—	—	+	"
Keranya ... M. 29 yrs. (7)	17.2.05	23	—	+	+	Slight incr.
	8.3.05	4	—	+	+	Great incr.
	12.3.05	Autopsy	—	—	—	"
Tumbo ... M. 10 yrs. (8)	6.3.05	48	+	+	+	Slight incr.
	19.4.05	4	—	+	+	Incr.
	22.4.05	Autopsy	—	—	+	Great incr.
Monica ... F. 12 yrs. (9)	20.2.05	29	—	+	+	Incr.
	7.3.05	14	—	+	+	"
	21.3.05	Autopsy	+	+	+	"
Jabolas ... M. 9 yrs. (10)	11.3.05	13	+	+	+	"
	24.3.05	Autopsy	—	—	+	"
Kenduga ... M. 24 yrs. (11)	20.3.05	34	+	+	+	"
	14.4.05	9	—	+	+	"
	23.4.05	Autopsy	—	...	+	Great incr.
Zerimenya ... M. 28 yrs. (12)	22.4.05	23	—	+	+	Incr.
	12.5.05	3	—	+	+	"
	15.5.05	Autopsy	+	—	+	"
Almasi ... M. 32 yrs. (13)	6.12.04	1	—	+	—	Great incr.
	7.12.04	Autopsy	—	—	—	"
Maharabu ... Swahili. M. 26 yrs. (14)	22.12.04	17	—	+	+	Great incr.
	9.1.05	Autopsy	—	—	—	"
Zake ... ... M. 23 yrs. (15)	11.5.05	6	+	+	+	Incr.
	17.5.05	Autopsy	—	—	+	Great incr.
Vule ... ... M. 21 yrs. (16)	9.3.05	11	—	+	+	"
	20.3.05	Autopsy	—	—	—	"

Name.	Date.	Number of days before death.	Trypanosomes		Cerebro-spinal fluid.	
			In Blood.	In Glands.	Trypanosomes.	Leucocytes.
Wasaneri ...	18.3.05	81	—	+	+	...
M. 26 yrs.	7.5.05	30	—	+	+	Incr.
(17)	31.5.05	6	—	+	+	Great incr.
	2.6.05	4	—	—	—	"
	6.6.05	Autopsy	—	—	—	"
Zakibu ...	9.5.05	...	—	+	+	...
M. 24 yrs.	9.6.05	...	+	+	+	Incr.
(18)	11.7.05	...	—	+	+	"
	8.8.05	Still alive.	—	—	+	"
Sururu	1.7.05	1	—	+	+	Great incr.
Morjan.	1.8.05	Autopsy	—	—	—	"
Nubian. M.						
(19)						
Vikitdyeya ...	8.5.05	20	—	+	+	Incr.
F. 23 yrs.	23.5.05	5	—	+	+	"
(20)	28.5.05	Autopsy	—	—	+	"
Thomasadi ...	26.5.05	30	—	+	+	"
M. 26 yrs.	25.6.05	Autopsy	—	—	+	"
(21)						
Busaja ...	16.1.05	165	—	+	—	Very few.
M. 19 yrs.	8.3.05	114	+	+	—	Slight.
(22)	6.5.05	55	—	+	+	"
	15.6.05	15	—	+	+	"
	29.6.05	1	—	+	+	Slight incr.
	30.6.05	Autopsy	+	+	+	"
Jabu Brahim	12.5.05	60	+	+	+	Incr.
Swahili.	2.6.05	32	+	+	+	"
M. 26 yrs.	4.7.05	Autopsy	—	—	+	"
(23)						
Hamesi ...	26.11.04	219	+	+	—	Very few.
M. 28 yrs.	28.12.04	187	+	+	+	"
(24)	24.2.05	153	+	+	+	Slight incr.
	13.5.05	61	—	+	+	Incr.
	17.6.05	18	+	+	+	Few.
	3.7.05	2	—	+	+	"
	5.7.05	Autopsy	—	—	+	Many.
Punda Mulia	14.7.05	72	—	+	+	Incr.
(25)	12.8.05	36	—	+	+	Large incr.
	17.9.05	Autopsy	—	—	—	"
Babula ...	23.11.05	1	+	+	+	Great incr.
(26)	24.11.05	Autopsy	—	—	—	"
Jumma ...	23.11.05	15	—	+	+	Incr.
(27)	7.12.05	1	—	+	—	"
	8.12.05	Autopsy	—	—	—	"

Name.	Date.	Number of days before death.	Trypanosomes		Cerebro-spinal fluid.	
			In Blood.	In Glands.	Trypano-somes.	Leucocytes.
Moanica ...	7.12.05	21	—	+	+	Incr.
M. 28 yrs.	28.12.05	Autopsy	—	—	+	Great incr.
(28)						
Upungu ...	8.5.05	...	—	+	+	Very scanty.
M. 20 yrs.	8.6.05	...	—	+	+	"
(29)	10.7.05	Still alive.	—	+	+	"
Sabakaki ...	25.5.05	...	+	+	+	Scanty
(30)	10.6.05	Still alive.	—	+	+	"
Manawa ...	9.6.04	...	—	+	—	Very few.
M. 25 yrs	10.5.05	...	—	—	—	"
(31)	16.6.05	...	—	—	+	...
	25.7.05	...	—	—	+	Very few.
	18.8.05	...	—	...	+	"
	23.9.05	...	—	...	—	"
	28.10.05	...	—	...	—	"
	7.12.05	...	—	—	—	"
	7.1.06	Still alive.	—	—	+	Slight incr.
Jordien	31.3.03	838	+	...	—	...
Murjan.	17.4.03	821	...	...	—	...
Nubian. M.	1.5.03	807	+	...	—	...
(32)	11.5.03	796	+	...	—	...
	25.5.03	782	+	...	—	...
	9.6.03	767	+	...	—	...
	23.6.03	753	+	...	—	Very few.
	22.7.03	724	+	...	+?	...
	18.8.03	697	+	...	+?	...
	21.9.03	663	+	...	—	...
	9.10.03	614	+	...	—	...
	26.12.03	566	+	...	+?	...
	1.2.04	530	...	...	—	...
	21.3.04	461	+	+	—	...
	7.6.04	383	+	+	+	Very few.
	18.7.04	342	—	+	+	"
	25.8.04	304	+	+	+	"
	2.10.04	266	+	+	+	...
	13.12.04	194	+	+	+	Incr.
	3.1.05	173	+	+	+	"
	8.4 05	78	...	+	+	"
	30.5.05	26	+	+	+	Great incr.
	26.6.05	Autopsy	—	—	+	"
Sengoma ...	9.5.05	170	+	+	+	Few.
M. 23 yrs.	7.6.05	141	—	+	+	"
(33)	7.7.05	111	—	+	+	Incr.
	4.8.05	83	—	+	+	"
	14.9.05	42	+	+	+	Great incr.
	25.10.05	1	—	+	+	"
	26.10.05	Autopsy	—	—	+	"

Name.	Date.	Number of days before death.	Trypanosomes		Cerebro-spinal fluid.	
			In Blood.	In Glands.	Trypanosomes.	Leuccoytes.
Mondu ...	9.7.04	533	+	+	—	Very few.
M. 25 yrs.	4.11.04	413	—	+	—	"
(34)	11.5.05	231	—	...	+	"
	14.6.05	191	—	...	+	Slight incr.
	11.7.05	165	—	...	+	"
	17.8.05	127	—	...	+	Incr.
	23.9.05	90	—	...	+	"
	28.10.05	55	—	...	+	"
	6.12.05	16	+	...	+	Great incr.
	22.12.05	Autopsy	—	...	+	"
Tenwa ...	7.6.04	...	—	+	—	...
M. 25 yrs.	4.11.04	...	—	—	—	...
(35)	10.5.05	...	—	...	+	Very few.
	10.7.05	...	—	...	—	Incr.
	18.8.05	...	—	...	+	"
	23.9.05	...	—	—	+	"
	28.10.05	...	—	—	—	Very slight.
	6.12.05	...	—	...	—	Slight incr.
	5.1.06	Alive	—	—	+	"
Rebani ...	10.1.06	1	+	—	—	Very scanty.
M. 35 yrs.	11.1.06	Autopsy	+	—	—	Scanty.
(36)						
Retero ...	6.12.05	...	—	+	+	Great incr.
M. 18 yrs.	5.1.06	Still	—	+	+	"
(37)		alive.				
Mataisa ... (38)	4.1.06	"	—	+	+	Very few.
Keosi ... (39)	4.1.06	"	—	+	+	Large incr
Lufumina ...	6.12.05	...	—	+	+	Incr.
(40)	15.1.06	Still	—	+	+	"
		alive.				
Zekya ...	10.1.06	...	+	+	—	Very few.
(41)	15.1.06	Still	—	+	—	"
		alive.				
Tabula ...	15.4.03	777	+	...	—	...
M.	6.5.03	756	...	...	—	...
(42)	25.6.03	706	—	...	—	...
	22.8.03	648	—	...	—	...
	5.1.04	523	...	...	—	...
	27.6.04	360	—	+	—	...
	5.12.04	189	—	+	—	...
	14.2.05	118	—	+	+	Incr.
	13.5.05	30	—	+	+	"

Name.	Date.	Number of days before death.	Trypanosomes		Cerebro-spinal fluid.	
			In Blood.	In Glands.	Trypanosomes.	Leucocytes.
Halone ...	18.1.06	Still alive.	—	+	—	Very few
Mr. Z. ...	26.5.05	"	+	+	—	"
Indian L.S. ...	19.1.06	"	+	+	—	"
Yusufu M. 16 yrs.	8.7.05	"	+	+	—	"

III.—*An analysis of* 32 post-mortem *examinations performed on cases of Sleeping Sickness.*

Out of a total of 32 *post-mortem* examinations made on cases of sleeping sickness since November, 1904, actively motile trypanosomes have been found in the cerebro-spinal fluid of 20. In 24 cases the examination was made within five hours after death, and in as many as 19 of these cases motile trypanosomes could be found in the cerebro-spinal fluid.

An analysis of these 32 *post-mortem* examinations shows—

Trypanosomes present in a blood film	5 times.
" " the brain	11 "
" " cerebro-spinal fluid ...	20 "
" " lymphatic glands	3 "
Diplo-cocci were present in the brain	22 "
" " " cerebro-spinal fluid ...	28 "
" " " spleen	27 "
Superficial ulceration of the stomach was found to be present	23 "
Complications sufficient in themselves to be a cause of death	7 "

These complications consisted of lobar pneumonia 2 ; purulent meningitis, 2 ; ulcerative endocarditis, 1 ; general acute pleurisy, 1 ; sarcoma of cervical glands, with deposits in liver and spleen, 1.

In the majority of cases the body showed marked emaciation, and bed-sores were often present.

The skin was generally very dry and harsh, old scabs and scratch marks being very common. The feet and sometimes the hands were frequently infested with "chiggers." The lymphatic glands, both superficial and deep, were always enlarged, this enlargement being especially noticeable in the deep cervical and axillary groups. In these regions the glands presented their characteristic soft, moveable character, were enlarged to some four or five times the normal size and were often hæmorrhagic on section. The glands of the groin were always enlarged but were generally hard or else showed points of suppuration due no doubt to the septic condition of the feet. Localised œdema was seen occasionally, two cases showing marked œdema of the feet. Œdema of the eyelids was a prominent feature in three cases. The pupils were never noticed to be unequal. The dura mater was often thickened and in places adherent to either the bone or pia arachnoid. The cerebro-spinal fluid was nearly always increased in amount and very cellular. The blood vessels on the surface of the brain were generally engorged. The lepto-meninges often showed patches of localised thickening and opacity, especially at the base of the brain. The brain substance appeared normal. The lungs were generally very œdematous and congested; old pleurisy was often seen. Minute petechial hæmorrhages were seen under the pleura on the surface of both lungs on several occasions. The heart was as a rule pale and flabby with its cavities somewhat dilated. The liver very often showed a "nutmeg" appearance on section. The spleen was constantly considerably enlarged and generally seemed congested. The mucous membrane of the stomach, as mentioned above, showed a varying amount of superficial ulceration in as many as 23 cases. (*See* Report VI., of Sleeping Sickness Commission of Royal Society, page 266.) We have not seen this condition of the stomach, so far, in the few *post-mortem* examinations we have witnessed, on natives who have died from diseases other than sleeping sickness.

A well marked small-celled infiltration around the blood vessels was seen in sections of those brains which were microscopically examined,—13 in all. Sections of these brains were stained by Leishman's method for demonstrating chromatin in sections, in the hope that trypanosomes would be observed in the brain substance. On one occasion only were we able to see trypanosomes in this way and then only in very scanty numbers. However, in smears of brain, trypanosomes have been seen in 11 cases, more often in smears from the brain surface than from the deeper parts. In examining these brains for trypanosomes our usual method has been to make emulsions of the various parts of the brain in normal citrate solution with the help of a pestle and mortar, to then centrifuge these emulsions and to examine drops of the resulting deposits fresh. If trypanosomes were found in any of these deposits, a drop of fresh blood serum was added, well mixed with the deposit and smeared out for staining.

Actively motile trypanosomes can nearly always be found somewhere in the body of a patient who has died of sleeping sickness, provided that the examination be made within an hour or two after death. In by far the greater number of cases these trypanosomes will be most easily found in either the cerebro-spinal fluid or emulsions of the brain substance. In our experience we have but rarely found parasites in the blood after death, and still more rarely in the lymphatic glands. In one case trypanosomes were numerous in the pericardial fluid as well as in the blood and cerebro-spinal fluid after death.

TABLE IV.

Showing the Results of the Post-mortem *Examination of the Blood, Brain, and Cerebro-spinal Fluid of* 32 *cases of Sleeping Sickness for* Trypanosoma gambiense.

Name	No. of Hours after Death.	Trypanosomes found in			
		Blood.	Brain.		Cerebro-spinal Fluid.
			Cortex.	Centre.	
1. Timateo	14	—	—	—	—
2. Abyabu	1	—	—	—	+
3. Badingo	1	...	...	...	+
4. Zenabu	3	+	—	—	+
5. Kaparaga	2	—	...	...	—
6. Suddwaka	1	—	...	...	+
7. Keranya	1½	—	...	...	—
8. Tumbo	½	—	+	—	+
9. Monica	½	+	—	...	+
10. Jabolas	3	—	—	—	+
11. Kenduga	½	—	+	—	+
12. Zerimenya	½	+	+	—	+
13. Almasi	10	—	—	—	—
14. Maharubu	12	—	...	...	—
15. Zake	3	—	+	—	+
16. Vule	1¼	—	—	—	—
17. Wasaneri	1	—	—	...	—
18. Sururu Morjan	12	—	—	+	—
19. Vikitdyeya	1	—	+	—	+
20. Thomasidi	4½	—	+	—	+
21. Busaja	½	+	+	—	+
22. Jabu	½	—	—	—	+
23. Hamesi	9½	—	+	—	+
24. Pundamulia	10	—	—	—	—
25. Babula	9	—	—	—	—
26. Juma	10	—	—	—	—
27. Moanica	3½	—	—	+	+
28. Jordien Murjan	1½	—	—	—	+
29. Sengoma	2½	—	—	—	+
30. Mondu	½	—	—	+	+
31. Rehani	½	+	—	—	—
32. Musajabura	4	—	—	—	+

IV.—*Human Trypanosomiasis and its relation to Sleeping Sickness.*

In June, 1903, Colonel Bruce and the other members of this Commission found trypanosomes in the blood of 23 persons, all but one of whom were natives of Africa. All these men then presented the ordinary symptoms of Trypanosoma fever, that is to say, they suffered from irregular periods of fever, headache and malaisè, their glands were enlarged and trypanosomes could be found in their blood at varying intervals. Unfortunately all traces of 10 of these individuals have been lost, but the remaining 13 have been under more or less continual observation, and their histories are very striking. At the present time (April, 1906) only one of these 13 men is alive, and he is now beginning to show symptoms of sleeping-sickness trypanosomes have been continually found either in his blood or glands from the very beginning. (*See* case, Kumsarsabba, page 24.)

Of the remaining 12 individuals, 10 have already died of sleeping sickness and two of pneumonia. The following table gives their names and the date of their death :—

TABLE V.

List of Individuals in whose blood Trypanosomes were first discovered in June, 1903, *giving the date and cause of death.*

Name.	Date of Death.	Cause of Death.
Mucase	Dec. 13, 1903 ...	Sleeping sickness.
Saulo	Dec. 2, 1903 ...	" "
Gabula	Jan. 1904	" "
*Karala Barigi	April 18, 1904 ...	Pneumonia.
*Bara Risgallah	May 5, 1904	"
Kululwe	Dec., 1904	Sleeping sickness.
Buza	March 2, 1905 ...	" "
Kitungula...	March, 1905	" "
Tevamukopi	April, 1905	" "
†Tabula	June 12, 1905 ...	" "
†Jordien Murjan	June 26, 1905 ...	" "
J. M. (European) ...	April, 1906	" "
Kumsarsabba	Alive on April 3, 1906, but is showing early symptoms of sleeping sickness.	

* For details *see* Report No. VI. of this series, page 40.
† A detailed account of these cases follows.

CASE 66. TABULA (MALE). AGE 25. TRYPANOSOMA FEVER.

District, Marine Village, Entebbe. Occupation, Marine.

April 15, 1903. Is a marine of one year's service, lives in the Marine Village where he says there are no cases of sleeping sickness. He used to live in Entebbe. He says that he has been ill for nine days and does not remember ever being ill before. He complains of slight headache. Pulse, 96; temperature, 100°; speech, quite normal; tongue moist and clean, not tremulous. There is no tremor of the fingers. Cervical lymphatic glands slightly enlarged. Enlarged glands in both groins. Trypanosomes are present in a blood film, but not in the cerebro-spinal fluid.

April 20. Temperature is normal to-day, having been persistently raised for the last five days.

May 11. Discharged from hospital to-day, his temperature having remained normal.

June 4. Temperature, 100·6°. Trypanosomes not present in the blood.

August 22. Patient is at his work and complains of nothing. His gait is normal, there is no tremor. His cerebro-spinal fluid has been examined five times since April, but has never shown the presence of trypanosomes.

November 13. Patient shows no signs of sleeping sickness; he is at his work and says that he is quite well. The occipital glands are slightly enlarged and those in the anterior triangle markedly so. The axillary and femoral glands are also enlarged. The fingers seem to be slightly tremulous. There is tremor of the tongue. The gait and expression are quite normal. There is no pain. Pulse, 80. Temperature, normal.

January 5, 1904. Complains of headache and pain in the eyes. Pulse, 68. Slight tremor of tongue and hands. Glands enlarged.

March 29. He is reported to be very dull and stupid at his work. Pulse, 80. Removed an enlarged lymphatic gland from the anterior triangle of the neck. Numerous and actively motile trypansomes are present in the gland juice. Tongue is tremulous.

June 13. Facial expression is dull. Tremor of tongue and hands. Pulse, 120. Lympathic glands generally enlarged in all the regions. Patient would not allow any examination of his cerebro-spinal fluid. Trypanosomes present in the gland juice and in a blood film.

June 27. Patient found asleep on duty. Examined cerebro-spinal fluid, trypanosomes are absent.

December 5. He is getting distinctly drowsy. Trypanosomes absent from the cerebro-spinal fluid.

February 8, 1905. Patient shows marked signs of sleeping sickness. Tremor of tongue and fingers has increased. He is drowsy, the voice is weak and his speech slow. The gland enlargement remains as before. Temperature, 104°. Admitted into the native hospital.

February 14. Removed 20 c.c. cerebro-spinal fluid. The cellular deposit is larger than before. Trypanosomes are present in moderate numbers. The cerebro-spinal fluid is under considerable pressure. It is sterile. Trypanosomes present in the lymphatic gland juice, but are absent from a blood film. Patient says that he feels weak and drowsy. He speaks normally, but his gait is uncertain. There is no wasting; his appetite is fairly good. He complains of headache. There is marked tremor of the tongue and fingers.

February 21. Injections of perchloride of mercury started.

March 4. Patient has had daily injections of mercury, $\frac{1}{12}$th grain, but without any marked effect. His temperature has varied between 99° and 101° every evening since admission.

May 13. Patient remains in much the same state. His temperature, though above normal, is not so high as it was. Drowsiness is increasing. Speaks in a very slow weak voice when roused. Tremor is marked. Examined the cerebro-spinal fluid; trypanosomes are present and numerous

June 3. Patient managed to crawl out of bed yesterday and fell down, cutting his head. The fall has been followed by twitching of all the limbs and choreiform movements which came on soon after the fall and which lasted many hours afterwards.

June 7. Patient's temperature has sunk to sub-normal and he is moribund.

June 8. Patient removed from the hospital in the night by his friends. A few days later news was brought that patient was dead, but a *post-mortem* examination was not allowed.

The following table shows the presence or absence of trypanosomes in the blood, glands, and cerebro-spinal fluid :—

Date.	Parasites in Blood.			Parasites in Glands.		Parasites in Cerebro-spinal Fluid.	
	Fil.	Mal.	Tryp.	Strept.	Tryp.	Strept.	Tryp.
1903.							
April 15	—	—	+	...	...	—	—
„ 17	...	...	...	...	...	...	...
May 6	...	...	...	...	...	—	—
„ 20	+	...	+	...	...	...	...
June 4	—	...	—	...	...	...	...
„ 25	+	...	—	...	...	—	—
Aug. 22	+	...	—	...	...	—	—
Sept. 25	+	...	+	...	...	...	...
Nov. 13	+	...	—	...	...	...	...
1904.							
Jan. 5	+	...	—	...	...	—	—
March 29	...	...	—	...	+	...	...
June 13	...	...	+	...	+	...	...
„ 27	...	...	—	...	+	—	—
Dec. 5	+	...	—	...	+	—	—
1905.							
Feb. 1	...	...	...	...	...	...	...
„ 8	...	...	+	...	+	...	...
„ 14	—	—	—	—	+	—	+
May 13	—	—	—	...	+	—	+

This man's temperature followed the usual course. There was constant fever for seven months before death. About a fortnight before death the temperature became sub-normal.

CASE 64. JORDIEN MURJAN. MALE. AGE 36.

District, Muru. Nubian. Prisoner for last three years.

March 31, 1903. Admitted to hospital. No œdema, no noticeable swelling of glands. Tongue healthy, but shaky. No tremor of hands. Speech is normal and pulse 144.

August 18. This patient at the present date has not any marked symptoms of sleeping sickness. At the same time, there is slight general enlargement of the lymphatic glands, his expression is dull, there is some tendency to tremor of the tongue and fingers, and his pulse is rapid.

September 21. Expression is dull and heavy. Complains of no pain. Appetite good. Pulse 136. Slight tremor of tongue and fingers.

November 9. No definite signs of sleeping sickness. Pulse 120. Fine tremor of tongue.

December 26. Tremor of fingers distinct. Trypanosomes present in the cerebro-spinal fluid.

February 1, 1904. General condition as before.

March 21. A gland in left anterior triangle of neck was removed ; active trypanosomes were present in the juice.

June 7. Pulse 104. No pain. Tremor of hands and tongue present. Œdematous swellings of both legs. Cerebro-spinal fluid contains active trypanosomes ; no red cells. He is reported to be " very dull and stupid and fit for very little work."

July 18. Complains of pain in head, arms and chest, also of itching. Pulse 125. Active trypanosomes in cerebro-spinal fluid ; no red cells in the deposit.

August 25. Complains of no pain. Pulse is 120. Œdema of right foot. Trypanosomes present in cerebro-spinal fluid ; no red cells.

October 2. Tremor of hand ; no pain. Slight œdematous swelling of left foot. Trypanosomes in cerebro-spinal fluid ; no red cells in deposit.

December 13. Pulse 110. Patient seems in just the same state. Œdema of both feet. Trypanosomes in cerebro-spinal fluid.

February 8, 1905. Pulse 100. Slight tremor of tongue and lips. Complains of nothing. Is reported to be very dirty and to do no work at all.

April 8. Face very dull looking and expressionless. Heavy tired look about the eyes. Complains of nothing, maintains a very sullen attitude. Gland enlargement quite marked on both sides of neck and in both axillæ. Glands soft and moveable. Skin very dry and harsh. Œdema of both feet and around both eyes. He is able to walk a short distance without any difficulty. Trypanosomes numerous in cerebro-spinal fluid.

May 1. Much worse. Can hardly walk at all. Tremor very distinct.

May 18. Patient admitted to the sleeping sickness hospital. Cannot stand without support. Appetite bad ; has lost flesh considerably of late. Much expectoration of very watery sputum. Pulse 120. Dulness of base of both lungs. Marked œdema of feet. Extreme tremor of tongue, lips, and hands. Knee jerks brisk. Pupils normal.

June 11. Patient is bedridden. Eats very little. Lies in a semi-conscious state the whole day. Extreme tremor when aroused. Complains of pain in his chest. He is getting very thin.

June 18. He is getting gradually weaker. Temperature remains between 95–96°. There is marked œdema around both eyes, of both feet and of the back.

June 26. Patient died at 4.30 a.m.

The following table shows the presence or absence of trypanosomes in the blood, lymphatic glands and cerebro-spinal fluid :—

Date.	Parasites in Blood.			Parasites in Glands.		Parasites in Cerebro-spinal Fluid.	
	Fil.	Mal.	Tryp.	Strept.	Tryp.	Strept.	Tryp.
1903.							
March 31	...	...	+	...	...	...	—
April 1	...	...	+	...	...	...	...
” 2	...	...	+	...	...	...	...
” 3	...	...	+	...	...	...	...
” 17	...	...	...	...	...	...	—
May 1	...	...	+	...	...	...	—
” 11	...	...	+	...	...	...	—
” 25	...	...	+	...	...	...	—
June 9	...	..	+	...	...	...	—
” 23	...	...	+	...	...	. .	—
July 22	..	...	+	...	...	. .	+
Aug. 18	...	...	...	...	...	...	+
Sept. 21	...	...	+	...	...	...	—
Nov. 9	...	...	+	...	...	...	—
Dec. 26	...	...	+	...	...	...	+

Date.	Parasites in Blood.			Parasites in Glands.		Parasites in Cerebro-spinal Fluid.	
	Fil.	Mal.	Tryp.	Strept.	Tryp.	Strept.	Tryp.
1904.							
Feb. 1	...	..	...	...	...	...	—
March 21	...	...	+	...	+	...	—
June 7	...	...	+	...	+	...	+
July 18	...	...	—	...	+	...	+
Aug. 25	...	...	+	...	+	...	+
Oct. 2	...	...	+	...	+	...	+
Dec. 13	...	...	+	—	+	—	+
1905.							
Jan. 3	...	...	+	—	+	—	+
Feb. 8	...	...	—	—	+	...	...
April 8	...	...	—	—	+	—	+
May 1	...	...	—	—	+	...	...
„ 18	...	...	—	—	+	...	...
„ 27	...	...	—	—	+	...	...
„ 30	...	...	+	—	+	—	+
June 8	...	...	—	—	+	...	...
„ 17	...	...	+	—	+	..	...
„ 21	...	...	—	—	+	...	...
„ 26	...	...	—	+	...	+	+

Since January, 1905, patient's temperature chart has shown constant slight evening elevations of temperature, which continued almost without interruption to the middle of May. During the third week of May there was a sharp rise, the temperature reaching 103°. The temperature became subnormal at the beginning of June, and remained in this condition until death.

June 26. *Post-mortem* examination 1½ hours after death.

The body is that of a well-nourished man, but rather thin. There is general enlargement of the superficial lymphatic glands. There is marked œdema around both eyes, more especially the right, and also œdema of the feet. The pupils are equal and normal.

Brain.—The dura-mater is adherent in places to the calvarium. The pia-arachnoid shows areas of thickening and opacity. The whole appearance of the brain is typical of sleeping sickness. Active motile trypanosomes are present in the cerebro-spinal fluid in moderate numbers. Stained films of this cerebro-spinal fluid deposit show a vacuolated trypanosome and a few scattered diplo-cocci. Trypanosomes can also be seen in stained films made from scrapings of the brain surface.

Lungs.—Are both very œdematous. The left pleural cavity contained twelve ounces of fluid. Trypanosomes could not be found in this fluid.

Lymphatic glands.—Are enlarged in the cervical and axillary regions. Some of these enlarged glands are hæmorrhagic on section. Trypanosomes could not be found in stained films made from the gland-juice.

The other organs of the body were all carefully examined and showed no abnormality.

Remarks.—This man originally came under observation as a case of Trypanosoma fever more than two years ago, since which time he has been continually under observation. His temperature has been taken every day, and his blood, glands and cerebro-spinal fluid have been regularly examined. Trypanosomes have been constantly found in either his blood, glands or cerebro-spinal fluid from the very beginning. For the last year, trypanosomes have been found in his cerebro-spinal fluid at every examination. Up to June, 1904, his temperature chart showed irregular periods of fever lasting for a day or two, an interval of one or two weeks of normal temperature usually intervening. From June, 1904, up to within a short time of death there has been constant daily fever, generally more marked towards evening and varying between 99° and 101°.

The patient's original slight symptoms very gradually increased in severity, the slight glandular enlargement became more marked, œdema of various parts of his body appeared, a constant daily pyrexia replaced the former irregular attacks of fever, and he became stupid, drowsy and unfit for any work. The original slight tremor grew very marked indeed; trypanosomes appeared in his cerebro-spinal fluid, and were afterwards constantly found there. Coma slowly developed, his temperature became sub-normal, and he died a typical case of sleeping sickness, amply confirmed at the autopsy.

CASE 63. KUMSARSABBA. MALE. AGE 25 YEARS.

Policeman. Nubian.

March 28, 1903. Admitted to hospital with fever. Temperature 102°. Says that he has never been ill before, now complains of headache.

History.—Has been in the police force for the last 11 months. Comes from Buddu. Does not know anybody with sleeping sickness. Is well-made and looks healthy. Tongue furred and said to be slightly tremulous. Lymphatic glands not enlarged in cervical region, but slightly in the groins. Walk normal. Speech also normal. No œdema of limbs or about the eyes. Heart and lungs normal. A blood-film examined by Dr. Baker showed the presence of trypanosomes.

March 30. Temperature has fallen to normal.

May 1. Temperature has remained normal for the last month. Patient seems quite well.

September 29. Patient says that he feels quite well. There are no signs of sleeping sickness. No headache or pain anywhere. Lymphatic glands are slightly enlarged in both posterior triangles, in axillæ and in both groins.

November 12. Condition unchanged. His cerebro-spinal fluid has now been examined six times, but trypanosomes have never been found in it. His temperature chart shows several sharp elevations of temperature to have occurred during the last eight months.

February 2, 1904. Patient remains in exactly the same state.

April 5. Lymphatic glands distinctly enlarged in left posterior triangle and in groin. Hands and tongue very slightly tremulous. Actively motile trypanosomes found in the gland-juice, examined to-day for the first time. Temperature remains about normal.

September 5. Glands enlarged as before; trypanosomes numerous in the gland-juice, but not present in the cerebro-spinal fluid, which is very clear and almost free from cellular deposit.

December 12. Temperature chart now shows slight daily elevations, which only rarely rise a degree or two above normal. General condition remains as before.

April 26, 1905. Glands enlarged as before. Slight œdema of both feet. Patient talks normally and says that he feels quite well. Actively motile trypanosomes present in the gland-juice. Tremor of hands and tongue very slight, if present at all. Temperature chart for the last four months still shows that patient's temperature is not quite normal, but that generally there is a slight evening rise.

July 20. Remains in exactly the same condition. Refuses to allow any more lumbar punctures to be performed, threatening to run away.

January 6, 1906. Temperature chart remains of the same character, showing a slight evening elevation. Trypanosomes are still present in the lymphatic glands and have always been found there at every examination. Patient looks well. He is reported to do his police work as well as ever. He complains of nothing.

March 1. Patient has been invalided from the police as not now fit for duty. Said by his native officer to have been formerly a very good shot, but to be now no good at all. Also reported to be lazy and careless. There is a heavy appearance about the man's eyes, though he says that he has no headache and feels well. His temperature chart has shown the same slight rise of an evening for the last three months. Tremor of the fingers is a little more marked than formerly. Patient has not lost flesh; he says his appetite is as good as ever. There is some fulness under the eyes, but no œdema anywhere else. Trypanosomes are still present in the gland-juice in considerable numbers, but cannot be found in a blood-film. He refuses to allow any examination of his cerebro-spinal fluid.

A photograph of Kumsarsabba has been taken to show his present healthy appearance in spite of the fact that trypanosomes have been continually found in either his blood or lymphatic glands for the last three years.

The following table shows the presence or absence of trypanosomes from the blood, glands and cerebro-spinal fluid of this patient:—

Date.	Parasites in Glands.		Parasites in Blood.			Parasites in Cerebro-spinal Fluid.	
	Strept.	Tryp.	Fil.	Mal.	Tryp.	Strept.	Tryp.
1903.							
March 28	...	...	...	...	+	...	...
May 7	...	...	...	...	—	...	—
16	...	...	...	...	—	...	...
„ 19	...	...	...	...	—	...	...
June 25	...	...	+	...	+	...	—
July 28	...	...	+	...	+	...	—
Aug. 19	...	...	...	...	...	...	—
Sept. 29	...	...	+	...	—	...	—
Nov. 12	...	...	—	...	—	...	—
„ 24	...	...	+	...	+	...	...
Dec. 27	...	...	+	...	—	...	—
1904.							
Feb. 2	...	...	+	...	+	...	—
April 5	...	+	—	...	—	...	...
Sept. 5	...	+	+	...	—	...	...
Dec. 12	...	+	...	...	—	...	—
1905.							
April 26	...	+	—	+	—	...	...
July 30	...	+	+	—	+	...	...
Dec. 20	...	+	+	—	—	...	...
1906.							
Jan. 6	...	+	—	—	—	...	...
March 1	...	+	+	—	—	...	...

In June, 1904, four Usoga prisoners were selected on account of typical gland-enlargement. Trypanosomes having been found in the glands of all of them, the men were placed in hospital and their temperatures were regularly taken. Their temperature charts showed irregular outbursts of fever every three or four weeks, the temperature remaining normal during the intervening periods. Trypanosomes were generally to be found in their blood during these outbursts of fever. This state of things continued up to November, 1904.* At the present time one of these four men has died of sleeping sickness, one escaped and has not been heard of for the last year, while the two remaining are still alive and are under observation in our hospital. A detailed report of these cases follows :—

CASE 310. MONDU. MALE. AGE 25.

District, Usoga.

July 8, 1904. This case, selected from a group of prisoners, showed general enlargement of the lymphatic glands, but no other signs of sleeping sickness. The juice from a gland in the right posterior triangle of the neck was examined and found to contain many active trypanosomes.

July 10. Intramuscular injections of arsenious acid were commenced.

October 10. General health of the patient good. Temperature has every night been above normal, but only occasionally higher than 100°. Patient has put on weight considerably.

November 4. Trypanosomes cannot be found in the cerebro-spinal fluid. Temperature remains consistently above normal at night.

January 20, 1905. Arsenic treatment recommenced. Patient remains in exactly the same state. There is no tremor, no headache, and he complains of nothing. The temperature still keeps consistently above normal ; on two or three occasions it has run up to nearly 103°.

April 25. Arsenic treatment stopped. Temperature has not been influenced by the arsenic treatment ; it is still consistently above normal. Trypanosomes have not been found in the blood or glands for four months. Patient is, however, so fat that it is impossible to puncture the glands with certainty.

May 11. Trypanosomes found in the cerebro-spinal fluid to-day for the first time. No parasites to be found in a blood-film. Patient complains of headache, remains exceedingly fat, has a good appetite and sleeps and walks normally. He works every day at clearing the grounds with the other prisoners.

August 17. Patient seems to be getting lethargic ; he sits and lies about most of the day. There is slight tremor of the tongue and lips. He has not lost flesh, but remains exceedingly fat. Trypanosomes have been found in the cerebro-spinal fluid at every examination since May, but they have not been found in the blood since January. It is impossible to examine the glands. Temperature remains above normal as before, and there have been several sharp rises.

October 28. Patient is very distinctly more dull and lethargic. He can still walk but only in an uncertain manner. He does no work. He remains just as fat as formerly. He still eats well, but sleeps a great deal. Trypanosomes are regularly present in his cerebro-spinal fluid, and in increasing numbers.

November 23. Patient has become rather suddenly much worse. He is semi-conscious. His temperature has become sub-normal. He only eats and drinks when food is forced upon him. He is covered all over with itch.

December 6. State of coma is slowly deepening. There is no rigidity or paralysis or optic deviation. Pupils are equal. Cerebro-spinal fluid contains trypanosomes in large numbers. There is a great increase in the amount of cellular deposit on centrifuging the cerebro-spinal fluid. Trypanosomes are also very numerous in a blood-film (since January, 1905, parasites had not been found in this patient's blood).

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* For detailed description of cases *see* Sleeping Sickness Report, No. VI., pages 50–64.

December 22. Patient died at 5 p.m. this afternoon.

The following table shows the results of the examinations for parasites in the blood, glands, and cerebro-spinal fluid of this case from December 1, 1904 :—

Date.	Parasites in Glands.		Parasites in Blood.			Parasites in Cerebro-spinal Fluid.		As_2O_3 in milli-grammes.
	Strept	Tryp.	Fil.	Mal.	Tryp.	Strept.	Tryp.	
Dec. 1...	—	—	—	—	—	...	...	None.
" 7...	—	—	—	—	—	...	...	"
" 31...	—	—	+	—	—	...	...	"
1905.								
Jan. 20...	—	—	—	—	+	...	...	10
" 24...	...	...	...	...	...	...	...	15
" 26...	—	—	—	—	—	...	...	20
" 30...	...	...	...	...	...	...	...	25
Feb. 2...	...	...	...	...	...	...	...	30
" 6...	—	—	+	—	—	...	...	30
" 8...	...	...	...	...	...	...	...	40
" 13...	—	—	—	—	—	...	...	40
" 17...	...	...	...	...	...	...	...	40
" 24...	...	...	...	...	...	...	...	35
March 3...	—	—	+	—	—	...	...	40
" 7...	...	...	...	...	...	...	...	45
" 13...	—	—	—	—	—	...	...	40
" 15...	...	...	...	...	...	...	...	40
" 17...	—	—	—	—	—	...	...	25
" 20...	...	...	...	...	...	...	...	15
" 25...	—	—	—	—	—	...	...	None.
April 29...	—	—	—	—	—	...	...	"
May 11...	—	—	—	—	—	—	+	"
" 18...	...	...	+	—	—	...	...	"
" 23...	...	...	—	—	—	...	...	"
June 3...	...	...	—	—	—	...	...	"
" 14...	...	...	—	—	—	...	+	"
" 21...	...	...	—	—	—	...	...	"
July 11...	...	...	—	—	—	...	+	"
" 22...	...	...	+	—	—	...	...	"
Aug. 17...	...	...	—	—	—	...	+	"
Sept. 23...	...	...	—	—	—	...	+	"
Oct. 28...	...	...	—	—	—	...	+	"
Dec. 6...	...	...	—	—	+	...	+	"
" 22...	...	...	—	—	—	+	+	"

From November, 1904, to the end of November, 1905, patient's temperature has been constantly about one-and-a-half or two degrees above normal. On three or four occasions bursts of fever lasting about forty-eight hours have occurred. On November 24, 1905, his temperature became sub-normal and remained so until death.

December 22. *Post-mortem* examination, half an hour after death.

The body is exceedingly fat. The superficial glands are impalpable, but on cutting down are found to be enlarged. The skin is dry and shows many scratch marks. The pupils are equal. The brain is congested and has the typical appearance of sleeping sickness. Trypanosomes can be found in the cerebro-spinal fluid in scanty numbers. Stained films of the various parts of the brain show that trypanosomes are present in the brain-nuclei, but cannot be found in other parts. Sections of the brain cortex and nuclei both show well marked small-celled infiltration around the cerebral blood vessels. The other organs showed nothing worthy of note.

When first seen this man appeared to be in perfect health. As his cervical glands were larger than normal, these were examined with the result that trypanosomes were found in the gland-juice. When his temperature was taken twice a day, it was found that his evening temperature was nearly always about 100°. Trypanosomes were found in his blood on four occasions when he first came under observation. Afterwards, trypanosomes were not found in the blood until a fortnight before death, when they were numerous. Not until seven months before death were trypanosomes found in his cerebro-spinal fluid. When the parasites had once been found there, they were always found on subsequent examinations, and in increasing numbers, up to a fortnight before death. After death trypanosomes could be found in the brain and cerebro-spinal fluid, but only in quite scanty numbers.

The whole course of the latter part of the disease was quite typical of sleeping sickness. Sections of the brain showed a very marked infiltration of small cells around the blood vessels in its substance.

The man died 18 months after he first came under our observation.

For the first 14 months, but for the fact of the constant evening rise of temperature and of occasional sharp short attacks of fever, the man was well. The treatment with arsenic did not seem to influence the course of the disease.

CASE 302. TENWA. MALE. AGE 25.

District, Usoga.

June 7, 1904. Patient was selected from a group of prisoners from Usoga, on account of enlarged glands in the neck. He asserts that he is quite well. Beyond general glandular enlargement, there are no signs of sleeping sickness. The lymph from a gland in the left posterior triangle of the neck was examined and found to contain many active trypanosomes.

October 16. General condition has improved considerably since admission. Slight elevations of temperature have occurred from time to time. At these times parasites have appeared in the blood. Weight 10 st. 5 lbs.

December 9. Evening temperature nearly always now about 100°. Patient feels and looks well, and shows no symptoms of sleeping sickness.

April 15, 1905. Temperature shows the same persistent rise in the evening. This morning the temperature is 101·6°, and trypanosomes are present in the blood. General condition remains unchanged. Weight, 10 st. 10 lbs.

May 10. For the first time trypanosomes found in the cerebro-spinal fluid, which is quite clear and watery ; there is only a very slight cellular deposit after centrifuging 20 cubic centimetres. Trypanosomes are not present in the blood.

September 23. Patient looks and feels as well as usual. There is no tremor and no loss of flesh nor symptoms of lethargy. There has been a continuous evening rise of temperature for a year.

January 11, 1906. Patient has not seemed quite so well lately. He is rather dull and stupid. His temperature chart still shows constant slight fever, but the variations are greater than formerly. There is no tremor. To-day his temperature has run up to 105° and trypanosomes are numerous in his blood.

Trypanosomes have been found in his cerebro-spinal fluid on four occasions since May, 1905, and on three examinations have proved negative.

The following table shows the presence or absence of parasites from his blood, glands, and cerebro-spinal fluid :—

Date.	Parasites in Glands.		Parasites in Blood.			Parasites in Cerebro-spinal Fluid.	
	Strept.	Tryp.	Fil.	Mal.	Tryp.	Strept.	Tryp.
Dec. 31	...	—	—	—	—	...	...
Feb. 13	...	—	+	—	—	...	...
" 18	...	...	—	—	—	...	...
March 14	...	—	—	—	—	...	...
" 17	...	—	...	...	...	...	...
April 15	...	...	+	—	+	...	...
" 20	...	—	+	—	—	...	...
May 4	...	—	...	...	...	...	...
" 10	..	...	+	—	—	...	+
" 16	...	...	—	—	—	...	...
" 27	...	...	+	—	—	...	...
June 3	...	...	+	—	—	...	...
" 21	...	...	+	—	—	...	...
July 10	...	...	+	—	—	...	—
" 23	...	...	+	—	—	...	...
Aug. 18	...	—	+	—	—	...	+
" 28	...	—	—	—	—	...	...
Sept. 23	...	—	—	—	—	...	+
Oct. 28	...	—	+	—	—	...	—
Dec. 6	...	—	—	—	—	...	—
Jan. 5	...	—	+	—	—	...	+
" 11	...	...	+	—	+	...	...

For the last 18 months patient's temperature has been constantly slightly above normal, varying between 99° and 101°. During this time there have been very occasional outbursts of high fever, lasting not more than 24 hours.

CASE 304. MANAWA. MALE. AGE 25.

District, Usoga.

June 12, 1904. This man was selected on account of enlarged glands in his neck. His general condition was good Gland-juice examined and found to contain many active trypanosomes.

October 16. The general health of the patient was good.

January 1, 1905. Evening temperature varies between 99° and 100°. Trypanosomes have not been found in the blood or glands since September last. There are no symptoms of sleeping sickness.

January 24. Intramuscular injections of arsenious acid commenced.

February 28. Arsenic treatment stopped.

May 10. Cerebro-spinal fluid examined but trypanosomes not present.

June 16. Trypanosomes found in the cerebro-spinal fluid to day for the first time. Temperature chart has shown a slight continual evening rise of temperature for the last eight months. Patient's general state remains as usual. There are no symptoms of sleeping sickness.

September 23. Condition good ; no symptoms of the disease. Trypanosomes cannot be found in either the cervical or axillary gland-juice. Glands are certainly not so much enlarged as they originally were.

January 10, 1906. Patient's condition remains unchanged ; his temperature chart presents the same characteristics as formerly. There are no symptoms of sleeping sickness. His cerebro-spinal fluid has been examined nine times, four times only with a positive result.

The following table shows the presence or absence of trypanosomes in his blood, glands and cerebro-spinal fluid and the amount of arsenic taken :—

Date.	Parasites in Glands.		Parasites in Blood.			Parasites in Cerebro-spinal Fluid.		As_2O_3 in milligrammes.
	Strept.	Tryp.	Fil.	Mal.	Tryp.	Strept.	Tryp.	
1904.								
Dec. 1 ...	...	...	+	—	—	...	...	
„ 7 ...	...	—	...	...	..	...	...	
„ 31 ...	...	...	+	—	—	...	...	
1905.								
Jan. 24 ...	...	—	+	—	—	...	...	During Jan., 65.
Feb. 2 ...	...	—	+	—	—	...	...	„ Feb., 310.
May 10 ...	...	—	+	—	—	..	—	
„ 18 ...	...	...	+	—	—	...	...	
June 3 ...	...	—	+	—	—	...	...	
„ 16 ...	...	...	+	—	—	...	+	
„ 21 ...	...	...	—	—	—	...	...	
July 25 ...	...	—	+	—	—	...	+	
Aug. 18 ...	...	—	—	—	—	...	+	
Sept. 23 ...	...	—	—	—	—	...	—	
Oct. 28 ...	...	—	+	—	—	...	—	
Dec. 7 ...	...	...	+	—	—	...	—	
1906.								
Jan. 5 ...	...	—	+	—	—	...	+	

Patient's temperature has exactly resembled that of the previous case (Tenwa), showing a similar constant elevation of temperature with occasional outbursts of high fever.

V.—*On the Treatment of Trypanosomiasis with Drugs in Men and in Animals.*

i. IN MEN.

(1) *Arsenic.*

We give a full account of a few early cases of trypanosome infection which we have been able to keep more or less continually under arsenic. We have used throughout a solution of arsenite of soda and common salt of such a strength that one cubic centimetre of the solution contained four milligrammes of arsenious acid. At first the drug was given as an intramuscular injection into the buttock. A single large dose given in this way was repeated, as a rule, every 48 hours. As we found it very difficult to get natives to submit to these repeated injections, we have lately tried giving this same solution by the mouth in smaller but more frequent doses.

The following table shows that the trypanosomes generally disappear from the blood and glands when this arsenic treatment is first started, but that in the majority of cases the parasites reappear again. In two cases (No. 6 and 7) the parasites have not reappeared in the blood or glands up to the present, and the patients continue in good health. Case 9 is disappointing, trypanosomes are constantly to be found in the glands in spite of the increasingly large doses of arsenic which are given.

Table VI.

Table showing the effects of arsenic on Trypanosoma gambiense.

Name of Case.	Month in which observations were made.	Trypanosomes in the lymph glands. No. of observations.	Trypanosomes in the lymph glands. Results.	Trypanosomes in blood. No. of observations.	Trypanosomes in blood. Results.	Amount of arsenic as arsenious acid in milligrammes.
	1904.					
Mondu, 1 ...	Jan.	2	2—	2	1+ 1—	100
	Feb.	2	2—	2	2—	215
	March	4	4—	4	4—	205
Marco, 2 ...	Nov.	3	3+	3	3—	90
	Dec.	4	2+ 2—	4	4—	101
	1905.					
	Jan.	2	2+	1	1—	38
	Feb.	2	2+	2	1+ 1—	85
	March	3	2+ 1—	3	3—	150
	April	1	1+	1	1—	20
	May	4	4+	3	3—	101
	June	3	3+			133
	July	2	2+			65
	Aug.	1	1+			105
	Sept.	2	1+ 1—	2	2—	78
	Oct.	1	1+			25
	Nov.	1	1+			50
	Dec.	1	1+			10
Zigudegen-eamba, 3	Jan.	1	1+	1	1+	75
	Feb.	2	2—	2	2—	110
	March	4	3+ 1—	2	2—	140
	April	2	2+	2	2—	46
	May	5	3+ 2—	1	1—	126
Gabouleri, 4 ...	April	2	2+	2	1— 1+	122
	May	1	1—	1	1—	186
	June	4	2+ 2—	4	4—	216
	July	4	2+ 2—	3	3—	220
	Aug.	2	2—	2	2—	210
	Sept.	2	2—	2	2—	120
	Oct.	2	2+	2	2—	86
	Nov.	1	1+	1	1—	none
	Dec.	2	2+	1	1+	80

Name of Case.	Month in which observations were made.	Trypanosomes in the lymph glands.		Trypanosomes in blood.		Amount of arsenic as arsenious acid in milligrammes.
		No. of observations.	Results.	No. of observations.	Results.	
	1904.					
Francisco, 5 ...	June	2	2+			24
	July	1	1+	1	1—	150
	Aug.	2	2+	2	2—	192
	Sept.	1	1+	1	1—	160
	Oct.	1	1+	1	1—	224
Martini, 6 ...	June	2	2+	1	1—	36
	July	1	1+	1	1—	220
	Aug.	1	1—	1	1—	230
	Sept.	2	2—	1	1—	240
	Oct.	1	1—	1	1—	232
Jakoasi, 7 ...	Feb.	2	2+	2	2—	80
	March	4	4—	4	4—	415
	April	6	3— 3+	4	4—	348
	May June July Aug. Sept. Oct. Nov. Dec.	14	14—	14	14—	none
Narain Singh, 8	June	1	1+	1	1—	34
	July	1	1+	1	1—	210
	Aug.	1	1—	1	1—	300
	Sept.	1	1+	1	1—	200
	Oct.	1	1+	1	1—	320
	Nov.	1	1+	1	1—	80
Ladha Singh, 9	April	3	1+ 2—	2	2—	126
	May	3	3+	3	3—	186
	June	1	1+	1	1—	240
	July	2	2+	2	2+	280
	Aug.	1	1+	1	1+	310
	Sept.	1	1+	1	1—	360
	Oct.	1	1+	1	1—	372
	Nov.	1	1+	1	1—	420
	Dec.	1	1+	1	1—	496

Cases 6, 7, 8, and 9 are now given in detail.

Cases 6 and 7 are interesting because arsenic seems to have had some considerable effect on their trypanosomes. Trypanosomes have not been found in case No. 7 for as long as ten months.

Cases 8 and 9 are of interest from the fact that the patients are both sepoys of the Indian contingent, and have only been in Uganda two years.

Martini. (No. 6.) Muganda Boy. 14 Years.

June 16, 1905. Lives in Entebbe, in shamba close to the lake-shore, near the Catholic mission. Sent up by the French fathers as a suspected case of sleeping sickness. Says that he sometimes has headache, but feels quite well now. Does not look ill. Says that he sleeps and eats well. There is no tremor. Patient does not seem dull or listless. There is marked enlargement of the cervical and axillary glands. Puncture left cervical gland. Trypanosomes are numerous in the gland-juice. Arsenic treatment started

August 19. General condition remains good. Trypanosomes cannot be found in the glands to-day.

September 15. Condition as before ; trypanosomes are still absent from the glands.

November 12. Patient having to leave for Kampala, arsenic treatment stops. His general condition good. Trypanosomes still absent from the glands. Pulse has always been about normal. No signs of sleeping sickness.

The following table shows the results of the blood and gland examinations, and also the amount of arsenic taken every month :—

Date.	Parasites in Glands.		Parasites in Blood.			Parasites in Cerebro-spinal Fluid.		Arsenious Acid in Milligrammes.
	Strept.	Tryp.	Fil.	Mal.	Tryp.	Strept.	Tryp.	
June 16 ...	...	+	—	—	—	...	...	During June, 36.
„ 21 ...	...	+	...	...	...	...	...	
July 19 ...	...	+	+	—	—	...	...	„ July, 220.
Aug. 18 ...	...	—	+	—	—	...	...	„ Aug., 230.
Sept. 4 ...	...	—	...	...	...	...	...	„ Sept., 240.
„ 15 ...	...	—	—	—	—	...	...	
Oct. 12 ...	...	—	...	...	...	...	...	„ Oct., 232.
Nov. 12 ...	...	—	+	—	—	...	...	

Jakoasi. Muganda Male. (Chief Mugula.) (No. 7.)

History.—Patient has lived in Entebbe all his life. Has been a porter for the last nine months. Says that he goes down to the lake-shore every day to wash his clothes about 2 p.m. Complains of fever, pains in the back of his head, and pain in the stomach for the last eight days.

February 21, 1905. *Condition.*—Tongue clean, not tremulous ; no tremor of the lips or fingers. Patient has a heavy look about the eyes ; walks normally. Says his appetite is good, that he has not vomited, that he does not feel sleepy, and that he only sleeps at night-time. Gland enlargement is marked in the cervical region, chiefly along posterior border of the sterno-mastoid, and at nape of neck, Glands are also enlarged in the right axilla, and slightly in both femoral regions. Glands are soft and movable. Joints are normal ; there is no œdema of hands, feet, &c. Skin is normal, it does not itch. Pulse 88. Temperature 99·2°. Respiration normal. Gland-juice shows many actively motile trypanosomes. Blood-film is negative. Patient was started on injections of arsenic, which were given intramuscularly about every third day.

March 6. Trypanosomes cannot be found in the glands to-day. Patient's general condition remains unchanged.

April 6. Trypanosomes, which up to to-day could not be found in the glands, have now reappeared. General condition remains satisfactory. Patient says that he feels better, and has no pain anywhere.

April 18. Trypanosomes have disappeared again from the glands. Patient complains of nothing ; says that he can do his work as well as ever.

June 22. Patient well. Trypanosomes absent from glands.

August 8. Patient returned from Kampala, where he has been since the middle of June. He is not taking any arsenious acid now. Trypanosomes cannot be found in his glands or blood. Patient is in good health. Lymphatic glands of the neck do not seen as large as formerly.

October 27. Appears in good health. Temperature 98·4°. Pulse 80. Trypanosomes not found in gland-juice or in blood.

December 5. Patient continues in the same satisfactory state, and says that he feels well. Trypanosomes still absent from the glands and blood.

The following table shows the presence or absence of trypanosomes in the blood and glands, and also the amount of arsenious acid taken per month :—

Date.	Parasites in Glands.		Parasites in Blood.			Arsenious acid in milligrammes.
	Strept.	Tryp.	Fil.	Mal.	Tryp.	
Feb. 21	...	+	+	—	—	
,, 23	...	+	+	—	—	During Feb., 80.
March 6	...	—	+	—	—	
,, 11	...	—	—	—	—	
,, 16	...	—	—	—	—	
,, 29	...	—	+	—	—	During March, 415.
April 6	...	+	—	—	—	
,, 8	...	+	—	—	—	
,, 10	...	+	—	—	—	
,, 18	...	—	—	—	—	
,, 21	...	—	+	—	—	
,, 29	...	—	—	—	—	During April. 348.
May 4	...	—	—	—	—	None.
,, 11	...	—	—	—	—	,,
,, 27	...	—	—	—	—	,,
June 2	...	—	+	—	—	,,
,, 10	...	—	—	—	—	,,
,, 22	...	—	—	—	—	,,
Aug. 8	...	—	—	—	—	,,
,, 19	...	—	—	—	—	,,
Sept. 1	...	—	—	—	—	,,
,, 12	...	—	+	—	—	,,
Oct. 4	...	—	—	—	—	,,
,, 27	...	—	+	—	—	,,
Nov. 15	...	—	—	—	—	,,
Dec. 5	...	—	—	—	—	,,

NARAIN SINGH. SEPOY INDIAN CONTINGENT, 4TH K.A.R. (NO. 8).

History.—Is a sepoy of seven years service. Comes from Sialkot in the Punjab. Always had good health while in India. Arrived at Mombasa in good health in March, 1904. On arrival in Uganda, was 10 days at Mununyo on baggage guard, living in a large grass hut on the lake shore in company with 20 other sepoys. (Mununyo, the port of Kampala, is infested with

Glossina palpalis.) He then came to Entebbe, where he lived in the Indian lines till January, 1905. While in Entebbe he was admitted to hospital as follows :—

April 13–16, 1904. Fever ; cause not diagnosed.

May 6–8, 1904. Fever (Malaria ?) ; blood not examined.

December 30–31, 1904. Abscess.

January 19–21, 1905. Fever ; cause not known.

January 26–28, 1905. Fever ; cause not known.

In February, 1905, he went to Kampala, where he again had fever.

June 22, 1905. Sent to us at Entebbe for examination with six other sepoys. Patient is thin, says that he is now quite well, but that he has had fever several times during the last four months. Is now doing ordinary duty, which he says that he can do easily. He has no pain ; eats and sleeps normally. Temperature 99°. Pulse 100. Respiration normal.

Tongue clean ; no tremor ; skin normal. Marked gland-enlargement on both sides of the neck and in both axillæ. Glands also enlarged in both groins, but only slightly. The glands are quite movable, soft and painless. There are no sores or scratches about the head or arms, and no œdema about the eyes or limbs. Blood examined with a negative result. Gland on right side of neck punctured ; trypanosomes found to be numerous in the gland-juice.

June 22. Patient put on injections of arsenious acid, given every other day, starting with 8 milligrammes, this dose being gradually increased.

July 3. Patient seems perfectly well. Complains of nothing. Temperature remains normal. Trypanosomes present in the glands.

August 8. Patient is now taking 20 milligrammes of arsenious acid every other day.

October 18. Temperature has been taken every four hours for the last fortnight. It is now seen to be not quite consistently normal, but shows a rise towards the middle of the day to about 99·4° or 99·8°. Patient remains in exactly the same state, insists that he is perfectly well. Trypanosomes are still present in his cervical glands.

November 13. Trypanosomes are still present in patient's glands ; a rat inoculated from patient's gland-juice, shows trypanosomes in its blood nine days later.

January 6, 1906. Patient's temperature has suddenly run up to 103·6°. His blood full of malaria (malignant tertian). Is given 10 grains quinine hypodermically. Trypanosomes not present in the blood.

The following table shows the result of the blood and gland examinations and also the amount of arsenious acid taken by the patient :—

Date.	Parasites in Glands.		Parasites in Blood.			Parasites in Cerebro-spinal Fluid.		Arsenic in Milligrammes.
	Strept.	Tryp.	Fil.	Mal.	Tryp.	Strept.	Tryp.	
June 22 ...	...	+	—	—	—	...	...	During June, 34.
July 24 ...	...	+	—	—	—	..	...	„ July, 210.
Aug. 25 ...	...	—	—	—	—	...	...	„ Aug. 300.
Sept 22 ...	...	+	—	—	—	...	...	„ Sept. 200.
Oct. 18 ...	...	+	—	—	—	...	...	„ Oct. 320.
Nov. 13 ...	...	+	—	—	—	...	...	„ Nov. 80.
Dec. 20 ...	...	+	—	—	—	...	...	None.

LADHA SINGH. SEPOY OF THE INDIAN CONTINGENT.

4th K. A. R. (No. 9.)

History.—General health in India good. Arrived at Mombasa in good health in March, 1904. Went straight to Kampala on arriving in Uganda. Was not on baggage guard at Mununyo with Narain Singh. From April, 1904, to January, 1905, lived in the Indian lines at Entebbe. While in Entebbe, was admitted to military hospital as follows :—

December 15–21, 1904. Fever ; cause not known

January 18–22, 1905. Fever ; cause not known. Says that he slept in the next bed to Narain Singh on this occasion.

January 28–31, 1905. Fever and headache ; cause not known.

February, 1905. Sent to Kampala.

February 19. Came under the care of Capt. R. H. Price, I.M.S., with fever, headache and vomiting.

February 28. A slide of patient's blood, sent in to us, was found to contain numerous trypanosomes.

March 3. Patient transferred to the military hospital, Entebbe, and put under our care.

March 4. Patient is a tall, thin, well made man. To-day he says that he feels well. Pulse, 86 ; Temperature, 98°·4 ; Respiration, normal. Says that his appetite is bad and that he has lost weight considerably. Suffers much from headache. Tongue rather furred, no tremor. No tremor of fingers. Knee jerks normal. Pupils normal. Edge of spleen can be felt just below costal margin. Liver impalpable. Pulse regular. Heart-sounds normal. Superficial glands on both sides of the neck and in both axillæ very considerably enlarged, soft, separate and movable. Gland on left side of neck was punctured, and trypanosomes were found to be numerous in the gland-juice. Blood-film shows trypanosomes in scanty numbers.

March 29. Temperature has run up again to 102°, having been about normal for the last ten days. Trypanosomes numerous in patient's blood.

April 18. Temperature up again to 102°·4. Trypanosomes numerous in blood and in glands. In spite of the temperature patient says that he does not feel at all ill. An injection of eight milligrammes of arsenious acid was given at 11.15, and at 12.15 trypanosomes could not be found in a blood-film.

May 10. Patient's temperature has been quite normal for a month. He is taking arsenious acid regularly.

July 20. An acute iritis of the left eye has developed to-day. Given atropine. Pupil dilates to an oval shape. Arsenic omitted for a time.

July 28. Eye seems well again.

September 8. An acute iritis of the right eye has developed to-day. Dr. Moffat saw patient to-day and considered that the iritis was due to spirillum fever, probably contracted at the beginning of the year. Trypanosomes numerous in the glands.

September 23. Patient complains of pain in the right foot. Dorsum of foot is swollen ; there is a red blush on the skin which disappears on pressure ; distinct œdema over the painful area. Left foot quite normal. No other similar places on his body.

September 27. Patient has been kept lying down for the last four days and his foot has been treated with lead and spirit lotion. The foot is now apparently well again. Ever since the latter part of May, temperature has been slightly above the normal in the evening, generally being about 99·4–100°.

October 17. Patient says he feels very well. Has no headache. Eats and sleeps well. Is taking 12 milligrammes of arsenious acid a day. His evening temperature has not been above 99° for a month.

December 3. Herpes zona present, starting at the base of the coccyx and spreading over right buttock and in right groin. Patient says he feels quite well otherwise. His evening temperature has been twice over 100° during the last six weeks. He is now taking 16 milligrammes of arsenious acid a day. Trypanosomes still present in the glands.

January 1, 1906. Arsenious acid increased to 24 milligrammes a day. Patient is in good health, complains of nothing.

The following table shows the results of the blood examinations and also the amount of arsenious acid taken every month :—

Date.	Parasites in Glands.		Parasites in Blood.			Parasites in Cerebro-spinal Fluid.		Arsenious acid in milligrammes.
	Strept.	Tryp.	Fil.	Mal.	Tryp.	Strept.	Tryp.	
1905.								
Feb. 28	...	...	—	—	+	...	...	
March 4	...	+	—	—	+	...	...	
,, 9	...	+	—	—	—	...	...	
,, 13	...	...	—	—	—	...	...	
,, 19	...	...	—	—	+	...	...	
April 7	...	...	—	—	+	...	...	During April. 126.
,, 18	...	+	...	...	...	...	...	
,, 25	...	—	—	—	—	...	...	
,, 28	...	—	—	—	—	...	...	
May 6	...	+	—	—	—	...	...	,, May, 186.
,, 10	...	+	—	—	—	...	...	
,, 31	...	+	—	—	—	...	...	
June 16	...	+	—	—	—	...	...	,, June, 240.
July 7	...	+	—	—	+	...	...	,, July, 280.
,, 17	...	+	—	—	+	...	...	
Aug. 9	...	+	—	—	+	...	...	,, Aug., 310.
Sept. 3	...	+	—	—	—	...	...	,, Sept., 360.
Oct. 17	...	+	—	—	—	...	...	,, Oct., 372.
Nov. 5	...	+	—	—	—	...	...	,, Nov., 420.
Dec. 3	...	+	—	—	—	...	...	,, Dec., 496.
1906.								
Jan. 3	...	+	—	—	—	...	...	
,, 19	...	+	...	...	...	...	—	

This man's temperature chart showed irregular sudden outbursts of fever during February and March, 1905, when he first came under our notice. All April, May, and June, his temperature was practically normal. Since June, 1905, his temperature has never been above 100·5°, but very constantly shows a slight evening rise above the normal.

(2) *Tragaroth.* (Ehrlich.)

In January, 1905, a supply of Tragaroth reached us, kindly sent by Professor Dr. P. Ehrlich. So far we have only had an opportunity of using this drug on cases in which marked symptoms of sleeping sickness have appeared. We give the notes of a few of the cases in which the drug has been administered. In one case the drug was given as a subcutaneous injection. An objection to this treatment is that the drug is only soluble in water to the extent of 1 per cent., and that the injection is therefore very bulky. In other cases the drug has been given by the mouth. We have never known Tragaroth to cause any ill effect even when taken in very large doses. We cannot say that the course of the disease has been influenced in any way in sleeping sickness patients who have taken this drug.

A native patient in an early stage of trypanosome infection, when possibly energetic treatment with drugs would be of some use, does not consider himself in any way ill and is very averse to a remedy of any description. If this remedy takes the form of painful injections often repeated, unless the patient really considers himself to be suffering from sleeping sickness, he will not submit to it. Up to the present time we have only been able to secure a very few prisoners in an early stage of trypanosome infection. These men are having their cerebro-spinal fluid examined regularly for the presence or absence of trypanosomes, and are not being treated with drugs.

BADINGO, KAVIRONDO. MALE. 38 YEARS.

Admitted October 3, 1904.

Has lived in Entebbe for the last five years, works close to the lake-shore. Has been ill for the last two months, and now complains of inability to do his work and of pains all over his body.

Facial expression dull; gait uncertain; skin very dry, but does not irritate. There is no œdema. Tongue clean, but very tremulous; there is tremor of the fingers and the knee jerks are brisk. No ankle clonus. Appetite good. Abdomen normal. Spleen cannot be felt. Heart and lungs appear normal. Superficial lymphatic glands generally enlarged and present the usual characters. Patient is thin, but not emaciated.

October 3, 1904. Cerebro-spinal fluid shows trypanosomes in moderate numbers. Trypanosomes are present in the gland-juice, but not in a blood film.

October 27. Two grammes of Trypanroth (Ehrlich) are injected under the skin into both axillæ in the form of a 1 per cent. solution in water. General condition as before. Patient shows only a very faint pink colour.

October 29. Pink colour much more marked. Trypanosomes cannot be found in the gland-juice.

November 25. Patient now much worse and cannot stand without support. The pink colouration from the Trypanroth has not yet disappeared. Cerebro-spinal fluid shows trypanosomes in about the same numbers as before. Fluid is more cellular than normal.

December 28. Patient has not got much worse during the last month. His temperature rose from sub-normal to 100·2°. Trypanosomes present in a blood-film, and in the cerebro-spinal fluid.

January 21, 1905. Patient lies in a stupor, cannot speak, can only just swallow. Cerebro-spinal fluid sterile, and contains trypanosomes in scanty numbers.

January 29. Patient died at 2 p.m.

The following table shows the presence or absence of trypanosomes in the blood, glands, or cerebro-spinal fluid :—

Date.	Parasites in Blood.			Parasites in Glands.		Parasites in Cerebro-spinal Fluid.		Trypanroth in Grammes.
	Fil.	Mal.	Tryp.	Strept.	Tryp.	Strept.	Tryp.	
1904.								
Oct. 3 ...	—	—	—	—	+	—	+	...
„ 27 ...	...	...	...	—	+	...	...	2
„ 28 ...	...	...	...	—	+	...	...	...
„ 29 ...	—	—	—	—	—	...	...	...
Nov. 5 ...	...	...	...	—	+	...	...	...
„ 18 ...	—	—	+	—	+	...	...	...
„ 25 ...	—	—	—	—	+	—	+	...
Dec. 14 ...	...	...	...	...	+	...	...	...
„ 28 ...	—	—	+	—	+	—	+	...

A *post-mortem* examination showed the brain to be very firm and fresh-looking ; the ground-glass appearance of cortex well marked and chiefly vertical in its distribution. Cerebro-spinal fluid is increased in amount, and there is slight flattening of the convolutions. Active trypanosomes are present in the cerebro-spinal fluid. Heart, normal ; lungs, no pleurisy, three triangular-shaped hæmorrhages (infarcts ?) at apex of right lung ; stomach, two well-marked patches of superficial ulceration on lesser curvature, ulcers small and lie on the folds of the stomach ; kidneys, liver, and spleen are all normal. Superficial glands are markedly enlarged in every region ; glands are not suppurating ; mesenteric glands appear normal.

The injection of the Trypanroth had only a slight temporary effect on the parasites in the peripheral circulation.

TUMBO. MALE. AGE 12.

District, Entebbe, Uganda.

February 27, 1905. Admitted to hospital. Patient says that for the last year he has been in the service of a resident at Entebbe. One of the other servants says that patient has been drowsy and stupid for the last two months. Patient is a short fat boy with a heavy dull look about the eyes. His speech is slow but distinct. He can walk normally. He complains of headache and of occasional pain in his stomach. There is slight tremor of the tongue and fingers. There is well marked gland enlargement in the cervical and axillary regions. Trypanosomes are present in the blood and gland-juice. Pulse, 80 ; temperature, 99·4°. Treatment with Tragaroth commenced ; drug given by the mouth in water.

March 6. Patient seems more drowsy than on admission. Trypanosomes are present in the cerebro-spinal fluid. There is a very marked increase of white cells in this fluid which are nearly all mono-nuclear.

March 16. Patient has now taken 60 grammes of Tragaroth by the mouth. His sclerotics are distinctly pink.

March 26. Patient has now taken more than 80 grammes of Tragaroth ; trypanosomes are still present in the gland-juice.

March 30. Patient is much worse. He is very tremulous and can hardly walk.

April 10. Complains of pain in the right hip, right knee and wrist. Purulent conjunctivitis of both eyes.

April 19. Trypanosomes are present in the cerebro-spinal fluid in increased numbers. Patient is moribund.

April 23. Died at 9 a.m.

The following table shows the presence of trypanosomes in the blood glands and cerebro-spinal fluid, and also the amount of tragaroth given :—

Date.	Parasites in Blood.			Parasites in Glands.		Parasites in Cerebro-spinal Fluid.		Tragaroth in Grammes.
	Fil.	Mal.	Tryp.	Strept.	Tryp.	Strept.	Tryp.	
1905.								
Feb. 27 ...	—	—	+	—	+	...	...	3
March 2 ...	...	...	...	...	...	...	...	6
,, 6 ...	—	—	+	—	+	—	+	9
,, 7 ...	...	...	...	...	...	...	...	6
,, 9 ...	...	...	...	...	...	...	...	6
,, 10 ...	...	...	...	—	+	...	...	5
,, 11 ...	...	...	...	—	+	...	...	5
,, 12 ...	—	—	+	...	...	...	...	5
,, 13 ..	...	...	...	...	...	...	...	5
,, 14 ...	...	...	...	—	+	...	...	5
,, 15 ...	...	...	...	...	...	...	...	5
,, 16 ...	...	...	...	—	+	...	...	2
,, 17 ...	—	—	—	...	...	...	...	2
,, 18 ...	...	...	...	—	+	...	...	3
,, 20 ...	—	—	—	—	+	...	...	3
,, 21 ...	...	...	...	...	...	...	...	3
,, 22 ...	...	...	...	...	. .	...	...	3
,, 24 ..	...	...	...	...	...	...	...	3
,, 26 ...	...	...	...	...	..	...	...	3
,, 28 ...	...	...	...	...	...	...	...	3
April 1 ...	—	—	+	—	+	...	...	3
,, 3 ...	—	—	+	...	...	...	...	3
,, 6 ..	—	—	—	—	+	...	...	...
,, 10 ...	—	—	—	—	+	...	...	...
,, 12 ...	—	—	—	...	...	...	...	...
,, 15 ...	—	—	—	—	+	...	...	...
,, 19 ...	—	—	—	—	+	—	+	...
								91 grms.

A *post-mortem* examination made half-an-hour after death. The body is still fat ; there is much muco-purulent conjunctivitis ; the red colouration caused by the Tragaroth has disappeared. Lungs, normal ; heart, normal ; pericardium contains a little blood-stained fluid. Trypanosomes are not present in this fluid. Spleen weighs 9 ounces ; some increase of fibrous tissue in its substance. Surface of the brain is quite typicsl of sleeping sickness. The cerebro-spinal fluid contains trypanosomes in considerable numbers. The surface of the brain and the cerebro-spinal fluid are sterile.

HAMESI. MALE. AGE 30.

District, Jinja, Usoga.

November 26, 1904. Admitted to hospital. Has lived at Jinja all his life. Has been a prisoner at Entebbe gaol for the last four months. Complains of headache and pains all over his body for the last two months. Patient looks somewhat dull and apathetic, his eyeballs are puffy and œdematous. There is no tremor. Liver and spleen are not palpable. The glands on both sides of neck and in the right axilla are enlarged. Trypanosomes are present in the gland-juice in large numbers, scantily present in a blood-film, and not present in the cerebro-spinal fluid.

December 28. Condition unaltered. Trypanosomes scantily present in the cerebro-spinal fluid. Patient complains of nothing.

February 24, 1905. Trypanosomes are present in the glands, blood and cerebro-spinal fluid. Treatment with Tragaroth commenced.

March 11. Patient has now had about 50 grammes of Tragaroth, by the the mouth. Sclerotics are pink.

April 6. Patient has now had 100 grammes of Tragaroth; the colouration from the drug is quite marked, but trypanosomes are still present in his glands.

April 18. Treatment with arsenic commenced.

April 27. He has had 70 milligrammes of arsenic in the last ten days. Trypanosomes have disappeared from the lymphatic glands.

May 13. Lumbar puncture again performed. The cerebro-spinal fluid is under considerable pressure. There is an increase of white cells in the deposit left after centrifuging the fluid. Trypanosomes are present. Trypanosomes cannot be found in either the blood or gland-juice. Patient has been taking arsenic regularly although not in such large doses as formerly.

May 30. Patient keeps to his bed much more than formerly and is now distinctly drowsy. Temperature has been subnormal on several occasions.

June 17. The drowsiness is steadily increasing. There is only slight tremor of the fingers. Trypanosomes are present in the cerebro-spinal fluid in increased numbers.

July 3. Patient is quite unconscious. Trypanosomes are still present in the cerebro-spinal fluid.

July 5. Patient died at 11 p.m.

The following table shows the presence or absence of trypanosomes in the blood, glands, or cerebro-spinal fluid, also the amount of arsenic and Tragaroth administered:—

Date.	Parasites in Blood.			Parasites in Glands.		Parasites in Cerebro-spinal Fluid.		Tragaroth in Grammes.
	Fil.	Mal.	Tryp.	Strept.	Tryp.	Strept.	Tryp.	
1904.								
Nov. 26	—	—	+	—	+	—	—	...
Dec. 7	—	—	+	—	+	...	...	...
” 28	—	—	+	—	+	—	+	...
1905.								
Jan. 14	—	—	—	—	+	...	...	...
Feb. 1	—	—	—	—	+	...	...	...
” 24	—	—	+	—	+	—	+	2·5
” 27	...	...	...	—	+	...	...	4
March 1	...	...	...	...	...	...	...	6
” 3	...	...	...	—	+	...	...	...
” 4	...	...	...	—	—	...	...	8
” 7	...	...	...	—	+	...	...	10
” 9	...	...	...	...	...	...	...	8
” 10	...	...	...	—	+	...	...	5
” 11	—	—	—	...	...	...	...	5
” 12	...	...	...	...	...	...	...	5
” 13	...	...	...	—	+	...	...	5
” 14	...	...	...	...	...	...	...	5
” 15	...	...	...	...	...	...	...	5
” 16	...	...	...	—	+	...	...	3
” 17	—	—	—	...	...	...	...	4
” 20	...	...	...	...	...	...	...	4
” 21	...	...	...	...	...	...	...	3
” 22	...	...	...	...	...	...	...	3
” 24	...	...	...	—	+	...	...	3
” 26	...	...	...	...	...	...	...	3
” 28	...	...	...	...	...	...	...	3
April 1	...	...	...	...	...	...	...	3
” 4	...	...	...	—	+	...	...	3
” 6	...	...	...	...	...	...	...	3
” 10	...	...	...	...	...	...	...	...
								103·5 grms.

Date.	Parasites in Blood.			Parasites in Glands.		Parasites in Cerebro-spinal Fluid.		Tragaroth in Grammes.
	Fil.	Mal.	Tryp.	Strept.	Tryp.	Strept.	Tryp.	
1905.								Arsenic in Milli-grammes.
April 12	—	—	—	—	+	...	...	...
,, 18	...	...	...	—	+	...	...	16
,, 20	...	...	...	—	+	...	...	22
,, 25	...	...	...	—	+	...	...	32
,, 27	...	...	...	—	—	...	...	16
,, 29	...	...	...	—	—	...	...	12
May 1	...	...	...	—	—	...	...	16
,, 5	...	...	...	—	—	...	...	10
,, 7	...	...	...	...	...	...	...	15
,, 9	...	...	...	...	...	...	...	20
,, 11	...	...	...	...	...	...	...	20
,, 13	—	—	—	—	+	—	+	...
,, 15	—	—	—	—	+	...	...	12
,, 17	...	...	...	...	...	...	...	15
,, 18	—	—	—	...	...	...	...	...
,, 19	...	...	...	...	...	...	...	15
,, 24	...	...	...	...	—	...	...	15
June 1	—	—	—	..	+	...	...	...
,, 8	—	—	—	...	+	...	...	...
,, 15	—	—	—	...	+	...	...	...
,, 17	—	—	+	—	+	—	+	...
,, 21	—	—	—	—	+	...	...	...
July 3	—	—	—	—	+	—	+	...
,, 5	—	—	—	+	—	+	+	...
								236 mgrms.

July 6. *Post-mortem* examination made nine-and-a-half hours after death. Body is very wasted and the eyes sunken. There is no œdema. The pupils are equal. There is general enlargement of the superficial lymphatic glands. Several opaque thickened patches are present on the pia-arachnoid, especially on the superior surface of the brain. Trypanosomes can be seen in smears of the brain-substance in scanty numbers. The stomach shows numerous small hæmorrhages on its internal surface. The spleen weighs 10 ounces. There is a marked increase of fibrous tissue on section of this organ. The cervical and axillary glands show general enlargement. Many of the glands are hæmorrhagic. Trypanosomes cannot be found in the gland juice. The other viscera appear healthy.

PAUL WAGANDA. MALE. 20 YEARS.

Lives in Kampala, but has been in Entebbe for the last eight months, where he lives near the French mission. Says that he has been ill for the last three weeks. Complains of pain in the limbs and back.

February 27, 1905. Patient says that he has been bitten by tsetse flies when he has gone down to the lake-shore to wash his clothes. He is well-nourished and looks well. Says that he has never had fever; that his appetite is good; that, except for the pain, he feels quite well; that he can do his work as well as ever, and that he only sleeps at night and does not feel drowsy during the day. Skin normal; no œdema. Pupils equal. Knee jerks normal. There is no tremor. Gland enlargement well-marked in cervical region on both sides, also in right axilla. Both epitrochlear glands enlarged. Temperature 99°. Pulse 88. Respiration normal. Gland juice shows many actively motile trypanosomes, but these are absent from a blood-film. Patient is given 4 grammes of tragaroth, dissolved in water, and flavoured with peppermint.

March 7. Trypanosomes present in blood and gland. Colour of mucous membranes unaltered.

March 20. Patient has had 52 grammes of tragaroth. The sclerotics have now a distinct red colour. Trypanosomes are present in the glands.

April 1. Patient's glands are still full of trypanosomes. He refuses to take any more medicine. Sclerotics are still a pink colour.

June 16. Glands show numerous trypanosomes. Patient is very dull and stupid. Tongue is slightly tremulous. He refuses to come into hospital.

The following table shows the results of the blood and gland examinations, and the amount of tragaroth taken by this patient :—

Date.	Parasites in Blood.			Parasites in Glands.		Parasites in Cerebro-spinal Fluid.		Tragaroth in Grammes.
	Fil.	Mal.	Tryp.	Strept.	Tryp.	Strept.	Tryp.	
1905. Feb. 27 ...	—	—	—	—	+	...	...	4·5
March 2 ...	...	...	...	...	...	...	...	4
„ 3 ...	...	...	...	...	...	...	...	4
„ 4 ...	...	...	...	...	...	...	...	5
„ 5 ...	...	...	...	...	...	...	...	5
„ 7 ...	—	—	+	—	+	...	...	5
„ 9 ...	...	...	...	...	...	...	...	5
„ 11 ...	...	...	...	...	...	...	...	5
„ 14 ...	...	...	...	...	...	...	...	5
„ 17 ...	...	...	...	...	...	...	...	5
„ 20 ...	—	—	—	—	+	...	...	5
April 1 ...	—	—	—	—	+	...	...	4
June 16 ...	—	—	—	...	+	...	...	...
								56·5 grms.

ii. IN ANIMALS.

(1) *Arsenic.*

Experiments were first conducted to discover the minimum lethal dose of arsenious acid for the species of monkey which we commonly use in our experiments. Eight monkeys were obtained and weighed, and then given varying doses of a solution of arsenious acid of a strength of two milligrammes of arsenious acid to the cubic centimetre. The drug was administered by subcutaneous injection. The following table gives the results of these experiments :—

TABLE VII.

No. of Animal.	Weight of Animal in kilogrammes.	Actual dose of Arsenious Acid given.	Ratio of Weight in grammes of animal per milligramme of Arsenious Acid.	Result.
A.	2·04	10 milligrammes	1 milligramme per 200 grammes	Died.
B.	1·24	5·5 ,,	1 ,, 225 ,,	Died.
C.	2·5	10 ,,	1 ,, 250 ,,	Died.
D.	1·24	5 ,,	1 ,, 250 ,,	Recovered.
E.	1·24	5 ,,	1 ,, 250 ,,	Recovered.
F.	1·23	5 ,,	1 ,, 300 ,,	Recovered.
G.	4·8	12 ,,	1 ,, 400 ,,	Recovered.
H.	3·52	7 ,,	1 ,, 500 ,,	Recovered.

From the above experiments it was found that a dose of arsenious acid in the proportion of one milligramme of arsenious acid per 250 grammes weight of monkey was the minimum lethal dose.

We give the details of four experiments in treating monkeys already infected with the trypanosome of sleeping sickness. Although arsenious acid was given in doses which were often repeated and in quantities not far short of the minimum lethal dose, yet in no case were we certainly able to cure the monkey. Experiment 415 was the most hopeful ; trypanosomes had been absent from this animal's blood for nearly three months as the result of the arsenic, and the animal was in good health when we lost him, as recorded. Experiment 370 is interesting as it shows that trypanosomes may return to the peripheral circulation, after a two months' absence, as a result of the treatment.

EXPERIMENT 405. MONKEY (*Cercopithecus sp.*) WEIGHT 3·85 KILOS.

May 23, 1905. 2 cubic centimetres of cerebro-spinal fluid taken from a case of sleeping sickness are injected subcutaneously into this monkey. Trypanosomes are not found in the blood.

July 1. Trypanosomes have appeared in the blood to-day for the first time

July 11. Arsenic treatment commenced. 4 milligrammes of arsenious acid are given equal to 1 milligramme per 960 grammes monkey.

August 15. Animal has now had 17 milligrammes of arsenious acid during the last month. General condition remains satisfactory. Treatment stopped.

September 12. Trypanosomes have re-appeared in the blood to-day.

December 10. Animal died to-day.

Post-mortem. Body rather emaciated. All the viscera appear healthy. Spleen not enlarged. Lymphatic glands normal. Sections of brain do not show any small-celled infiltration. Trypanosomes were present in the blood up to the time of death in scanty numbers.

The following table shows the presence or absence of trypanosomes from the blood and also the amount of arsenious acid given :—

Date.	Parasites in Blood.		Arsenious Acid in milli-grammes.	Date.	Parasites in Blood.		Arsenious Acid in milli-grammes.
	Mal.	Tryp.			Mal.	Tryp.	
1905.							
May 23 ...	...	—	...	Aug. 8 ...	...	—	...
„ 29 ...	...	—	...	„ 15 ...	...	—	3
June 3 ...	...	—	...	„ 24 ...	...	—	...
„ 10 ...	...	...	...	„ 30 ..	...	—	...
„ 21 ...	...	...	...	Sept. 11 ...	...	+	...
„ 26 ...	...	...	...	„ 12 ...	...	+	3
July 1 ...	. .	+	...	„ 20 ...	...	—	...
„ 7 ...	...	+	...	„ 26 ...	...	—	...
„ 11 ...	...	+	4	Oct. 3 ...	...	—	...
„ 16 ..	...	—	...	„ 10 ...	...	+	...
„ 20 ...	...	+	3	„ 20 ...	...	+	...
„ 25 ...	...	+	3	Nov. 12 ...	...	+	...
„ 30 ...	...	—	...	„ 24 ...	...	+	...
Aug. 6 ...	...	+	...	Dec. 10 ...	...	+	...

EXPERIMENT 415. MONKEY (*Cercopithecus sp.*). WEIGHT 1·81 KILOS.

May 23, 1905. 2 cubic centimetres of cerebro-spinal fluid from a case of sleeping sickness injected subcutaneously. Trypanosomes absent from blood.

June 13. Trypanosomes have been constantly present in the blood up to to-day. Arsenious acid now administered in doses of 4 milligrammes, which equals 1 milligramme per 450 grammes monkey.

July 20. Animal has had 12 milligrammes of arsenious acid since the treatment was started. Arsenic stopped.

September 8. Animal eaten by a jackal in the night. Trypanosomes had not been found in the animal's blood since the arsenic treatment was started.

The following table shows the presence or absence of trypanosomes from the animal's blood, and also the amount of arsenious acid given :—

Date.	Parasites in Blood.		Arsenious Acid in milli-grammes.	Date.	Parasites in Blood.		Arsenious Acid in milli-grammes.
	Mal.	Tryp.			Mal.	Tryp.	
1905.				1905.			
May 23 ...	...	—	...	July 16 ...	...	—	...
June 7 ...	...	+	...	„ 20 ...	...	—	2
„ 13 ...	...	+	4	„ 25 ...	...	—	..
„ 14 ...	...	—	...	„ 30 ...	...	—	...
„ 24 ...	...	—	...	Aug. 6 ...	...	—	...
July 1 ...	...	—	4	„ 15 ...	...	—	. .
„ 7 ...	...	—	...	„ 24 ...	...	—	...
„ 10 ...	...	—	2	Sept. 8 ...	...	—	...

EXPERIMENT 370. MONKEY (*Cercopithecus sp.*).

April 5, 1905. A few drops of blood from monkey 350, containing numerous trypanosomes, were injected into this animal.

April 10. Trypanosomes have appeared in the animal's blood to-day for the first time.

May 14. Trypanosomes have been constantly present in this animal's blood up to to-day. Weight of animal is 1·72 kilogrammes. Injected subcutaneously arsenious acid 4 milligrammes, which equals 1 milligramme per 400 grammes monkey.

May 15. Monkey seems sick to-day, and has been purged freely in the night. Trypanosomes cannot be found in the blood to-day.

July 10. Trypanosomes have reappeared in the animal's blood to-day. For the last two months parasites have not been found in the blood.

August 8. Animal found dead this morning. At the autopsy it was found that the animal's rectum had been perforated by the constant use of the clinical thermometer. There was much peritonitis present, otherwise all the viscera were healthy.

The following table shows the presence or absence of trypanosomes from the animal's blood, and also the amount of arsenious acid given :—

Date.	Parasites in Blood.		Arsenious Acid in milli-grammes.	Date.	Parasites in Blood.		Arsenious Acid in milli-grammes.
	Mal.	Tryp.			Mal.	Tryp.	
1905.				1905.			
March 13 ...	...	—	...	May 31 ...	...	—	3
„ 22 ...	...	—	...	June 7 ...	...	—	3
April 5 ...	...	—	...	„ 12 ...	...	—	...
„ 10 ...	...	+	...	„ 18 ...	...	—	...
„ 15 ...	...	+	...	„ 26 ...	...	—	...
„ 21 ...	...	+	...	„ 30 ...	...	—	...
„ 28 ...	...	+	...	July 10 ...	...	+	3
May 5 ...	...	+	...	„ 16 ...	...	—	...
„ 14 ...	...	+	4	„ 20 ...	...	—	...
„ 15 ...	...	—	...	„ 30 ...	...	—	...
„ 24 ...	...	—	3	„ 4 ...	...	—	...
„ 29 ...	...	—	..	„ 8 ...	...	—	...

This monkey was treated with frequently repeated large doses of arsenious acid. Trypanosomes disappeared from the blood for two months, but reappeared again as soon as the treatment was given up for a while.

EXPERIMENT 421. MONKEY. (*Cercopithecus sp.*). WEIGHT 1·04 KILOS.

May 31, 1905. 3 cubic centimetres of cerebro-spinal fluid taken from "Wasaneri," a case of advanced sleeping sickness, were injected into this animal in whose blood trypanosomes were ascertained to be absent.

June 13. Trypanosomes have appeared in the blood to-day for the first time.

July 11. Trypanosomes have now been present in the animal's blood for more than a month. 3 milligrammes of arsenious acid (=1 milligramme per 350 grammes monkey) were injected.

July 12. Trypanosomes have disappeared from the blood.

July 25. Monkey has had 7 milligrammes of arsenious acid in 14 days. Trypanosomes have remained absent from the blood.

September 12. Trypanosomes have reappeared in the animal's blood to-day, having been absent for two months.

September 26. Monkey has had six additional milligrammes of arsenious acid during the last fourteen days. Trypanosomes have again disappeared from the blood.

November 23. Trypanosomes have reappeared to-day, having been absent for 2½ months. Animal remains in good health.

The following table shows the results of the blood examinations, and the amount of arsenious acid given :—

Date.	Trypanosomes in Blood.	Arsenious Acid in Milligrammes.	Date.	Trypanosomes in Blood.	Arsenious Acid in Milligrammes.
1905.			1905.		
May 31	—	...	Sept. 12	+	3
June 13	+	...	,, 19	—	...
,, 24	+	...	,, 26	—	3
July 11	+	3	Oct. 3	—	...
,, 16	—	...	,, 20	—	...
,, 20	—	2	,, 29	—	...
,, 25	—	2	Nov. 16	—	...
,, 30	—	...	,, 23	+	...
Aug. 6	—	...	Dec 1	—	...
,, 13	—	...	,, 14	—	...
,, 24	—	...	,, 18	+	...
,, 31	—	...			

Has arsenic any value as a prophylactic against the trypanosome of sleeping sickness in the case of monkeys?

We give the details of some experiments which were conducted to determine whether a monkey which was under the influence of arsenic could yet be infected with the trypanosome of sleeping sickness. Seven monkeys were used in these experiments. One of them was kept as a control, and was simply inoculated with a similar dose of cerebro-spinal fluid as was given to the other monkeys which were under the influence of arsenic. The control monkey showed trypanosomes in its blood 23 days after inoculation. Three of the other monkeys showed trypanosomes in their blood in spite of the previous doses of arsenious acid, but in these the appearance of the trypanosomes in the blood was much delayed. Two of the animals never showed trypanosomes in their blood, and in their cases, no doubt, the arsenic did protect the animals from infection; but in these two cases very large and dangerous doses of arsenious acid had been given, and the animals were made seriously ill by the drug. A similar dose given to the sixth and last monkey proved fatal. From these experiments we are brought to the conclusion that ordinary safe doses of arsenic given to monkeys before inoculation with human trypanosomes have little or no power in protecting the animals from subsequent infection.

Experiment 336. Monkey (*Cercopithecus sp.*). Weight 1·24 kilos.

December 3, 1904. 5 milligrammes of arsenious acid were injected subcutaneously, which equals 1 milligramme per 250 grammes monkey.

December 4. Animal has had a good deal of diarrhœa in the night.

December 6. 4 milligrammes of arsenious acid administered.

December 19. 4 milligrammes of arsenious acid given.

December 21. 3 cubic centimetres of cerebro-spinal fluid were injected subcutaneously from a case of sleeping sickness (Abyabu), containing numerous trypanosomes.

February 13. Monkey is rather thin but otherwise healthy. Trypanosomes have not yet appeared in the blood.

February 21. Trypanosomes have appeared in the blood to-day for the first time (62 days after inoculation).

The following table shows the results of the blood examinations, and the amount of arsenious acid given :—

Date.	Parasites in Blood.		Parasites in Cerebro-spinal Fluid.		Arsenious Acid in millegrammes.
	Mal.	Tryp.	Strept.	Tryp.	
1904.					
Dec. 3	...	...	...	...	5
„ 16	...	...	...	...	4
„ 19	—	—	...	...	4
„ 21	Inoculated with trypanosomes.				...
„ 30	—	—	...	...	...
1905.					
Jan. 5	—	—	...	...	...
„ 13	—	—	...	...	..
„ 24	—	—	...	...	..
„ 30	—	—	...	...	...
Feb. 8	—	—	...	...	...
„ 13	—	—	...	...	...
„ 21	—	+	...	...	...

The arsenic evidently prolonged the incubation period of the disease in this case.

Experiment 347. Monkey (*Cercopithecus sp.*). Weight 1,920 Grammes.

December 12, 1904. 4 milligrammes of arsenious acid, *i.e.*, 1 milligramme per 480 grammes monkey, were injected.

December 19. 6 milligrammes of arsenic, *i.e.*, 1 milligramme per 320 grammes monkey, were injected. Blood examined; trypanosomes are absent.

December 21. Injected subcutaneously 3 cubic centimetres of cerebro-spinal fluid from sleeping sickness case (Abyabu), containing numerous trypanosomes.

January 30. Trypanosomes appeared in the blood for the first time to-day, 40 days after inoculation.

March 20. Animal died to-day

The following table shows the presence or absence of trypanosomes in the blood :—

Date.	Parasites in Blood.		Parasites in Cerebro-spinal Fluid.		Arsenious Acid in mille-grammes.
	Mal.	Tryp.	Strept.	Tryp.	
1904.					
Dec. 12	...	...	...	...	4
„ 19	+	—	...	...	6
„ 21	Inoculated with trypanosomes.				...
„ 30	+	—	...	...	...
1905.					
Jan. 5	+	—	...	...	...
„ 13	+	—	...	...	...
„ 23	+	—	...	...	...
„ 30	+	+	...	...	...
Feb. 5	+	+	...	...	...
„ 8	+	+	...	...	...
„ 13	+	+	...	...	...
„ 17	+	+	...	...	...
„ 21	+	+	...	...	...
March 1	+	+	...	...	...
„ 8	+	+	...	...	...

Post-mortem examination (eight hours after death) Animal thin and very anæmic. No glandular enlargement. Trypanosomes not present in a blood-film. All the organs seem healthy, but anæmic. Spleen somewhat enlarged. Intestines contain a long tape-worm. Brain appears normal. No trypanosomes in the cerebro-spinal fluid.

EXPERIMENT 348. MONKEY (*Cercopithecus sp.*). WEIGHT 1,020 GRAMMES.

December 19, 1904. Injected 4 milligrammes arsenic, which equals 1 milligramme per 255 grammes monkey.

December 21. Animal ill. Extensive purging. Injected 3 cubic centimetres cerebro-spinal fluid from case of sleeping sickness (Abyabu) containing numerous trypanosomes.

December 23. Animal found dead this morning.

Post-mortem. Stomach shows marked patches of erosion ; contains some altered blood. Liver, pale ; has a flea-bitten appearance. Intestines show many inflamed patches. Trypanosomes are absent from the blood. This animal almost certainly died from the effects of the arsenic, given 3½ days previously.

EXPERIMENT 342. MONKEY (*Cercopithecus sp.*). WEIGHT 1,460 GRAMMES.

December 7, 1904. A maximum dose of arsenic—6 milligrammes (which equals 1 milligramme per 243 grammes monkey)—was injected.

December 8. Animal very weak and ill, has had much diarrhœa in the night.

December 12. Animal seems well again. Arsenic 4 milligrammes.

December 19. Arsenic 6 milligrammes.

December 21. Injected subcutaneously, three cubic centimetres of cerebro-spinal fluid from sleeping sickness case (Abyabu), containing numerous trypanosomes.

March 24. Animal's blood has been examined carefully every week since the day of inoculation. Trypanosomes have never been found in the blood. Animal, though thin, remains in good health.

The following table shows the dates and result of the blood examinations :—

Date.	Parasites in Blood.		Parasites in Cerebro-spinal Fluid.		Arsenious Acid in milligrammes.
	Mal.	Tryp.	Strept.	Tryp.	
1904.					
Dec. 7	...	...	...	...	6
„ 12	...	...	...	...	4
„ 19	+	—	...	...	6
„ 21	Inoculated with trypanosomes.				...
„ 30	+	—	...	...	...
1905.					
Jan. 5	+	—	...	...	...
„ 13	+	—	...	...	...
„ 23	+	—	...	...	...
„ 30	+	—	...	...	...
Feb. 8	+	—	...	...	...
„ 13	+	—	...	...	...
„ 21	+	—	...	...	...
March 1	+	—	...	...	...
„ 8	+	—	...	..	...

EXPERIMENT 349. MONKEY (*Cercopithecus sp.*). WEIGHT 1,030 GRAMMES.

December 19, 1904. Injected arsenic 4 milligrammes, *i.e.*, 1 milligramme per 260 gramme Monkey.

December 21. Animal ill. Some diarrhœa. Injected subcutaneously 3 cubic centimetres cerebro-spinal fluid from case of sleeping sickness (Abyabu), containing numerous trypanosomes.

December 30. Animal seems to have recovered from the arsenic. Trypanosomes are absent from the blood.

February 4. Animal died to-day. Blood has been examined every week, but trypanosomes have never been found in it. This animal stood captivity badly, and has got progressively thinner. There is a large sore on it's abdomen where the collar was attached.

The following table shows the result of the blood examinations :—

Date.	Parasites in Blood.		Parasites in Cerebro-spinal Fluid.		As_2O_3 in milligrammes.
	Mal.	Tryp.	Strept.	Tryp.	
1904.					
Dec. 19	—	—	...	...	4
„ 21	Inoculated with trypanosomes.				...
„ 30	—	—	...	...	...
1905.					
Jan. 5	—	—	...	...	...
„ 13	—	—	...	...	...
„ 24	—	—	...	...	...
„ 30	—	—	...	...	...
Feb. 4	—	—	...	...	...

Post-mortem examination (one hour after death). Animal very anæmic and wasted. Blood-film shows no trypanosomes. Organs pale, but not unhealthy. Intestine contains a large tape-worm. Trypanosomes not present in the cerebro-spinal fluid. Brain appears normal.

EXPERIMENT 341. MONKEY. MALE. (*Cercopithecus sp.*) WEIGHT 3·5 KILOS.

December 7, 1904. Injected arsenic, 5 milligrammes, equal to 1 milligramme of arsenic per 700 grammes monkey, and just half the maximum dose.

December 9. Inject 2 cubic centimetres of blood from Kitsame (an early case of trypanosome infection).

December 23. Trypanosomes appeared in the blood to-day.

December 27. Trypanosomes numerous in blood. Inject arsenic, 7 milligrammes.

January 13. Trypanosomes again present in the blood, having been absent for the last 17 days.

January 14. Inject arsenic 8 milligrammes.

February 4. Animal died to-day. Trypanosomes have been absent from the blood since the last injection of arsenic.

The following table shows the presence or absence of trypanosomes in the blood :—

Date.	Parasites in Blood.			Parasites in Cerebro-spinal Fluid.		As_2O_3 in milligrammes.
	Fil.	Mal.	Tryp.	Strept.	Tryp.	
1904.						
Dec. 16	—	+	—	...	...	...
„ 23	—	+	+	...	...	...
„ 27	—	+	+	...	...	7
„ 29	—	+	—	...	...	...
„ 31	—	+	—	...	...	...
1905.						
Jan. 5	—	+	—	...	...	...
„ 13	—	+	+	...	...	...
„ 14	—	+	+	...	...	8
„ 17	—	+	—	...	...	...
„ 21	—	+	—	...	...	...
„ 23	—	+	—	...	...	...
„ 29	—	+	—	...	...	...
Feb. 4	—	+	—	—	—	...

Post-mortem examination. Heart, normal ; lungs, very pale ; a few scattered petechiæ in the pleuræ. Stomach shows no ulceration, but a few flecks of altered blood here and there. Liver has an abscess, the size of two walnuts, at the lower border of the liver substance. Contents consist of thick yellow curdy pus. A smear shows the presence of a large Diplococcus. Kidneys, normal. Lymphatic glands not enlarged. Brain appears quite normal. Trypanosomes appeared in the blood of this animal fourteen days after inoculation, in spite of the large dose of arsenic which had been given 36 hours before.

EXPERIMENT 350. MONKEY (*Cercopithecus sp.*). CONTROL.

December 21, 1904. Blood examined. Trypanosomes are absent. Injected subcutaneously 3 cubic centimetres of cerebro-spinal fluid from sleeping sickness case (Abyabu), containing numerous trypanosomes.

January 13. Trypanosomes appeared in the blood to-day for the first time.

March 8. Animal is getting thin. Trypanosomes have been continuously present in the blood.

April 4. Animal died to-day.

The following table shows the presence or absence of trypanosomes in the blood :—

Date.	Parasites in Blood.		Parasites in Cerebro-spinal fluid.		As_2O_3 milligrammes.
	Mal.	Tryp.	Strept.	Tryp.	
1904.					
Dec. 19...	+	—	...	...	None.
„ 21...	Inoculated with trypanosomes.				
„ 30...	+	—	...	...	
1905.					
Jan. 5...	+	—	...	...	
„ 13...	+	+	...	...	
„ 23...	+	+	...	...	
„ 30...	+	+	...	...	
Feb. 5...	+	+	...	...	
„ 13...	+	+	...	...	
„ 21...	+	+	...	...	
March 1...	+	+	...	...	
„ 8..	+	+	...	...	
„ 17...	+	+	...	...	
„ 28...	+	+	...	...	
April 4...	+	+	...	...	

Post-mortem examination (one hour after death). Animal thin and anæmic. Blood-film contains trypanosomes in large numbers. No superficial glandular enlargement. Brain appears normal. Specimen of cerebro-spinal fluid contains a little blood ; trypanosomes are present in it, but not in very large numbers. Stomach.—A few minute points of superficial ulceration are scattered over the mucous membrane. Each ulcer is covered with a point of blood clot. All other viscera normal.

(2) *Trypanroth* (Ehrlich).

We have injected several fresh monkeys with a solution of trypanroth with a view to ascertaining how much of this drug can be safely given to these animals. Unfortunately, many of our monkeys so injected developed large abscesses at the seat of injection, and in some cases died from the effects of such abscesses. Monkeys injected in this way became deeply pigmented all over, the pigmentation getting to its full depth in 48 hours.

TABLE VIII.

To show the effects of different doses of Trypanroth on Monkeys.

Letter of Animal.	Weight of Animal.	Trypanroth, 2 per cent. solution.	Trypanroth per weight of Monkey.	Result.
A.	3·64 kilos.	25 cubic centimetres.	1 milligramme per 7·5 grammes monkey.	Died.
B.	1·36 "	7 cubic centimetres.	1 milligramme per 10 grammes monkey.	Fatal in 12 days. Abscess formed.
C.	1·8 "	9 cubic centimetres.	1 milligramme per 10 grammes monkey.	Fatal in 7 days from abscess.
D.	1·25 "	5 cubic centimetres.	1 milligramme per 12·5 grammes monkey.	Died a month later for no apparent reason.

From these experiments it seems that 1 milligramme of trypanroth per 12 grammes monkey is about the minimum lethal dose.

We give the account of an experiment in which a monkey suffering from the trypanosome of sleeping sickness was unsucessfully treated with a solution of trypanroth. The trypanosomes disappeared for a time but returned to the circulation in 12 days.

EXPERIMENT 314. MONKEY (*Cercopithecus sp.*).
WEIGHT 1·786 KILOGRAMMES.

August 15. Blood examined; trypanosomes absent. Inject 5 cubic centimetres of blood, containing numerous trypanosomes, from sleeping sickness case (Abyabu).

August 26. Trypanosomes have appeared in the blood to-day for the first time, 11 days after inoculation.

October 26. For the last two months, trypanosomes have been continually present in the animal's blood. Inject subcutaneously 10 cubic centimetres of 1 per cent. solution of trypanroth (*i.e.* 1 milligramme trypanroth per 17·8 grammes monkey).

October 28. Animal's skin has a deep red colour. Site of inoculation appears healthy. Trypanosomes absent from blood.

November 2. Animal seems none the worse for the drug. Trypanosomes are still absent from the blood.

November 7. Trypanosomes have reappeared in the blood again to-day. Animal's skin is still of a deep red colour.

December 19.—Trypanosomes have been constantly present in the blood since November 7. Inject 5 milligrammes arsenic (*i.e.* 1 milligramme per 160 grammes monkey). This dose proved fatal to the monkey.

VI. *On the Identity of the Trypanosome of Sleeping Sickness with* Trypanosoma Gambiense ;

An account of Inoculation Experiments on 32 *Rats and on a Chimpanzee.*

Following the suggestion of the Tropical Diseases Committee of the Royal Society, that there might be more than one species of human trypanosome in Uganda, we have inoculated white rats with human trypanosomes from as many sources as possible. White rats were used because of the recent announcement by Mr. Plimmer, that these animals react very differently to *Trypanosoma gambiense* on the one hand and to the trypanosome of Uganda sleeping sickness on the other, the author reporting that white rats inoculated with the former trypanosome die in a little more than two months, with swarms of parasites in their peripheral blood, while those infected with the latter parasite die with paralysis of the hind limbs, and with parasites only to be found in the spinal cord, six to nine months after inoculation.

The rats used by us have all been bred out in Entebbe from parents sent to us from England. They were not used for inoculation experiments until they were at least four months old. Our stock of uninoculated rats has always been very healthy; we have not lost a single uninfected animal from intercurrent disease. All rats inoculated with different strains of human trypanosome have been kept apart in separate cages, and each rat has been identified by its sex, &c., and by cuts or other marks in one or both ears.

We have inoculated rats from the following sources :—

A. *The cerebro-spinal fluid of sleeping sickness patients.*
B. *The blood of monkeys infected from the cerebro-spinal fluid of sleeping sickness patients.*
C. *The blood of sleeping sickness patients.*
D. *The blood of patients with trypanosomiasis, but with no symptoms of sleeping sickness.*
E. *The blood of monkeys infected from the blood of trypanosomiasis patients, with no symptoms of sleeping sickness.*
F. *The gland-juice of patients with sleeping sickness.*
G. *The gland-juice of patients with trypanosomiasis, but with no symptoms of sleeping sickness.*

Of 32 rats inoculated with trypanosomes from these seven sources, all but 13 have shown trypanosomes in their peripheral blood since inoculation. Four of these 13 may yet do so, as it is only a few weeks since they were inoculated.

Class A.—Of six rats inoculated, only two have shown trypanosomes in their peripheral blood. In these two rats the parasites have always been very scanty. All the rats remain healthy.

Class B.—Consisted originally of four rats all inoculated with blood from a monkey infected with cerebro-spinal fluid from a typical case of sleeping sickness. The blood used to inoculate them was taken from the monkey two months after it had been infected with the cerebro-spinal fluid. The blood was moderately rich in trypanosomes at the time. Trypanosomes appeared in the blood of these four rats ten or eleven days after inoculation, to reappear at intervals and in very scanty numbers up to the time of death. All these rats showed paralysis of their hind limbs for ten or more days before their death, which occurred from three to four months after inoculation. In three out of the four animals, trypanosomes could not be found in the peripheral blood at the time of death. In the fourth, trypanosomes were present in very scanty numbers.

When examined after death, trypanosomes were found to be present in the brains and spinal cords of these four rats in considerable numbers. Sections of these brains and spinal cords, stained by Leishman's special method, showed trypanosomes scattered all through the nervous matter, apparently more numerous in the brain than in the spinal cord. Trypanosomes could not be seen in the brain capillaries. The sections of all four brains showed small-celled infiltration around the blood vessels in the brain-substance, the typical lesion of sleeping sickness.

Other rats inoculated with trypanosomes from these paralysed rats have shown trypanosomes in their blood in much greater numbers and far oftener than was the case with the original rats. One of these rats so inoculated has already died, and is worthy of notice. Trypanosomes appeared in its blood 33 days after inoculation with a few drops of spinal-cord emulsion, taken *post-mortem* from one of the paralysed rats. Trypanosomes became more and more numerous in this animal's blood until death occurred just two-and-a-half months from the time of inoculation. At death the spleen was enormously large, the liver was considerably enlarged and the blood swarmed with parasites. This rat never showed any signs of paralysis.

Class C.—Four rats have been inoculated with blood from sleeping sickness patients in the last stage of the disease, but trypanosomes have not appeared in their blood up to now.

Class D.—Four rats were inoculated from the blood of an Indian, who simply showed fever and trypanosomes in his blood, in July, 1905. Only one of these rats has ever shown trypanosomes in its blood since inoculation. For six-and-a-half months this rat remained in good health, showing trypanosomes in its blood at rare intervals. It then developed paralysis of the hind limbs, and died on March 1, 1906, with numerous trypanosomes in the brain and spinal cord.

Class E.—A single rat in this class shows scanty parasites in its blood. It remains in good health.

Class F.—Two rats inoculated with the gland-juice of advanced cases of sleeping sickness have not yet shown trypanosomes in their peripheral blood. Both these rats remain healthy.

Class G.—Two rats inoculated with the gland-juice taken from very early cases of trypanosome-infection show trypanosomes in their blood at rare intervals, and at present remain healthy.

It is evident that, on examining the history of the rats in class B, one and the same strain of trypanosome, obtained originally from a case of sleeping sickness (cerebro-spinal fluid), has produced death in similar animals in two distinct and very different ways. The mode of death in the first four rats corresponds to that accredited by Plimmer to the trypanosome of Uganda sleeping sickness. The disease, death and *post-mortem* appearances in the other rats inoculated from one of the above, are identical with what have often been described for rats inoculated with the trypanosome of Gambia fever. So the same strain of trypanosome has in this way been made to produce the two different effects which were brought forward in support of the theory that the parasite of Gambia fever was distinct from that of Uganda sleeping sickness. It seems also that rats inoculated with trypanosomes from the spinal-fluid of sleeping sickness cases as well as rats inoculated with blood from cases of Trypanosoma fever may both die with marked symptoms of paralysis.

From these experiments we infer that there is only one variety of human trypanosome in Uganda, and that it is identical with *Trypanosoma gambiense.*

The following table gives an outline of our experiments on these white rats, and after it we describe a few of the more interesting experiments in detail :—

TABLE IX.

Class A.

Rats Inoculated with Cerebro-spinal Fluid from Sleeping Sickness cases.

Number of Experiment.	Date of Inoculation.	Date of appearance in Peripheral Blood.	Number of Parasites usually seen.	Result. Date of Death.
449	1905. July 14	Never shown parasites.		Alive and well, March, 1906.
450[°]	" 14	1905. Aug. 2 ... (19 days.)	Only shown on three occasions, very scantily.	Alive and well, March, 1906.
479	Sept. 14	Oct. 21 ... (37 days.)	Shown twice, very scanty.	Alive and well, March, 1906.
480	" 14	Never shown parasites.		Died on Dec. 1, 1905, in giving birth.
541	Dec. 6	Not yet shown parasites.		Alive and well, March, 1906.
542	" 6	" "	"	Alive and well, March, 1906.

[°] In these tables case marked with an asterisk are subsequently given in fuller detail.

Class B.

Rats Inoculated with Blood from Monkeys, which had been previously Inoculated with Cerebro-spinal Fluid from Sleeping Sickness Patients.

Number of Experiment.	Date of Inoculation.	Date of appearance in Peripheral Blood.	Number of Parasites usually seen.	Result. Date of Death.
		FIRST PASSAGE.		
451	1905. July 17	1905. July 28 ... (11 days.)	Shown several times; parasites always scanty.	Died Nov. 6, 1905, with paralysis.
452	" 17	July 27 ... (10 days.)	Shown several times; parasites always scanty.	Died Oct. 19, 1905, with paralysis.
453 (*a*)	" 17	July 27 ... (10 days.)	Shown several times; parasites always scanty.	Died Nov. 6, 1905, with paralysis.
453 (*b*)[*]	" 17	July 27 ... (10 days.)	Shown several times; parasites always scanty.	Died Oct. 26 1905, with paralysis.
509	Oct. 20	Nov. 28 ... (39 days.)	Shown parasites once only.	Alive and well, March, 1906.
		SECOND PASSAGE.		
512[*] (From 453 (*b*) above.)	Oct. 26	Nov. 7 ... (12 days.)	Parasites generally present, often numerous.	Alive and well, March, 1906.
513[*] (From 453 (*b*) above.)	" 26	Nov. 28 ... (33 days.)	Parasites very numerous, increasing till death.	Died Jan. 8, 1906. No paralysis, large spleen, blood swarming with trypanosomes.
514[*] (From 453 (*b*).)	" 26	Nov. 22 ... (27 days.)	Often numerous.	Alive and well, March, 1906.
519 (From 453 (*a*).)	Nov. 6	Nov. 22 ... (16 days.)	Often numerous.	Alive and well, March, 1906.
520 (From 453 (*a*).)	" 6	Nov. 16 ... (10 days.)	Generally scanty.	Alive and well March, 1906.
		THIRD PASSAGE.		
526 (From 514.)	Nov. 29	Dec. 12 ... (13 days.)	Moderate numbers.	Alive and well, March, 1906.
527 (From 514.)	" 29	1906. Jan. 9 ... (41 days.)	Scanty numbers.	Alive and well, March, 1906.
546. (From 513.)	Dec. 28	Jan. 2 ... (5 days.)	Rather scanty at present.	Alive and well, March, 1906.

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[*] In these tables case marked with an asterisk are subsequently given in fuller detail.

Class C.

Rats Inoculated with Blood taken from Sleeping Sickness Patients, and containing Trypanosomes in moderate numbers.

No. of Experiment.	Date of Inoculation.	Date of appearance in Peripheral Blood.	Number of Parasites usually seen.	Result.
516	1905. Oct. 30	Never shown parasites		Alive and well, March, 1906.
517	„ 30	„ „ „		Alive and well, March, 1906.
543	Dec. 7	Not yet shown parasites		Alive and well, March, 1906.
544	„ 7	„ „ „		Alive and well, March, 1906.

Class D.

Rats Inoculated from Patients showing Trypanosomes in their Peripheral Blood, but with no symptoms of Sleeping Sickness.

No. of Experiment.	Date of Inoculation.	Date of appearance in Peripheral Blood.	Number of Parasites usually seen.	Result. Date of Death.
455	1905. July 17	Never shown parasites		Alive and well, March, 1906.
456	„ 17	„ „ „		Alive and well, March, 1906.
457	„ 17	„ „ „		Alive and well, March, 1906.
458[*]	„ 17	1905. Aug. 12 ... (26 days.)	Showed for a month in moderate numbers; not shown for three months.	Developed paralysis of hind limbs in Jan., 1906, and died on March 1, 1906.

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[*] In these tables cases marked with an asterisk are subsequently given in fuller detail.

Class E.

Rat Inoculated with Blood from Monkey infected with Blood from Patient showing no signs of Sleeping Sickness, but whose Blood contained Trypanosomes.

No. of Experiment.	Date of Inoculation.	Date of appearance in Peripheral Blood.	Number of Parasites usually seen.	Result.
545	1905. Dec. 12	1906. Jan. 3 ... (22 days.)	Scanty at present.	Alive and well, March, 1906.

Class F.

Rats inoculated with Gland-Juice from Patients suffering from Sleeping Sickness.

No of Experiment.	Date of Inoculation.	Date of appearance in Peripheral Blood.	Number of Parasites usually seen.	Result.
508	1905. Oct. 20	Never shown parasites		Alive and well, March, 1906.
523	Nov. 15	" "	"	Alive and well, March, 1906.

Class G.

Rats Inoculated with Gland-Juice from Patients with Trypanosomiasis, but who show no signs of Sleeping Sickness.

No. of Experiment.	Date of Inoculation.	Date of appearance in Peripheral Blood.	Number of Parasites usually seen.	Result.
503	1905. Oct. 10	1905. Nov. 1 ... (22 days.)	Only shown once, in very scanty numbers.	Alive and well, March, 1906.
521	Nov. 13	Nov. 22 ... (9 days.)	Shown twice, very scantily.	Alive and well, March, 1906.

Details of some of the Experiments shown in the foregoing tables :—

Class A.

No. 450. Rat (White). Male. Right Ear cut.

July 14, 1905. Inject subcutaneously the deposit from 10 cubic centimetres of cerebro-spinal fluid left after centrifuging, taken from a case of well-marked sleeping sickness. Trypanosomes are present in this deposit in moderate numbers.

August 2. Trypanosomes have appeared in the blood to-day in scanty numbers.

October 4. Animal remains in good health. Trypanosomes are not to be found in the blood.

November 1. Trypanosomes again present in the blood in very scanty numbers.

January 9, 1906. Animal remains in apparently perfect health.

The following table shows the result of the blood examinations :—

Date.	Trypanosomes.	Date.	Trypanosomes.	Date.	Trypanosomes.
1905.		1905.		1905.	
July 14 ...	—	Aug. 14 ...	—	Nov. 1 ...	+
" 21 ...	—	" 16 ...	—	" 12 ...	—
" 23 ...	—	" 19 ...	—	" 16 ...	—
" 25 ...	—	" 22 ...	+	" 22 ...	—
" 27 ...	—	" 27 ...	—	" 28 ...	—
" 29 ...	—	Sept. 1 ...	—	Dec. 5 ...	—
" 31 ...	—	" 6 ...	—	" 12 ...	—
Aug. 2 ...	+	" 13 ...	—	" 20 ...	—
" 4 ...	—	" 20 ...	—	" 27 ...	—
" 6 ...	—	" 27 ...	—		
" 8 ...	—	Oct. 4 ...	—	1906.	
" 10 ...	—	" 19 ...	—	Jan. 3 ...	—
" 12 ...	—	" 25 ...	—	" 9 ...	—

Class B.

No. 453 (*b*). Rat (White). Female. Right Ear notched.

July 17, 1905. Inject subcutaneously three drops of blood and citrate solution from monkey 420.

July 27. Trypanosomes scantily present in the blood to-day.

October 19. There is well-marked paralysis of the hind limbs. Otherwise animal seems fairly well. Trypanosomes have not been found in the blood since Sept. 6.

October 23. Animal is getting thin and seems very sick. Extreme paralysis of hind limbs.

October 26. Animal moribund, and killed.

The following table shows the presence or absence of trypanosomes in the blood :—

Date.	Trypanosomes.	Date.	Trypanosomes.	Date.	Trypanosomes.
1905.		1905.		1905.	
July 21 ...	—	Aug. 19 ...	+	Sept. 27 ...	—
" 23 ...	—	" 23 ...	—	Oct. 4 ...	—
" 25 ...	—	" 27 ...	—	" 11 ...	—
" 27 ...	+	Sept. 1 ...	—	" 19 ...	—
Aug. 4 ...	—	" 6 ...	+	" 20 ...	—
" 8 ...	+	" 13 ...	—	" 25 ...	—
" 16 ...	—	" 20 ...	—	" 26 ...	—

October 26. *Post-mortem* examination, immediately after death. The animal is decidedly thin. No œdema of the body wall. Eyes normal. No enlargement of the superficial lymphatic glands. The coat is rough and full of lice. All the viscera of the thorax and abdomen appear quite healthy Spleen a little larger than normal. Brain and spinal cord appear normal to the naked eye. Trypanosomes not present in a blood-film. Emulsions in normal citrate solution were then made of the brain, spinal cord and thoracic and abdominal viscera. These emulsions having been centrifuged, the deposits were examined. Trypanosomes were found to be numerous in the brain, to be present in moderate numbers in the spinal cord and to be scanty in the other viscera. Other rats were inoculated with portions of these emulsions. Sections of the brain and spinal cord, stained by Leishman's method, showed well-marked small-celled infiltration around the cerebral blood-vessels. Numerous trypanosomes could be seen scattered all through the brain-substance.

Class B.

SECOND PASSAGE.

NO. 513. RAT (BLACK AND WHITE). MALE. BOTH EARS CUT.

October 26, 1905. Inject subcutaneously a few drops of an emulsion in normal citrate of the spinal cord of rat 453 (*b*).

November 28. Trypanosomes have appeared in the animal's blood to-day.

December 27. Trypanosomes have now become numerous in this animal's blood. Animal seems in good health.

January 4, 1906. Trypanosomes have now become about half as numerous in the blood as the red corpuscles. A few nucleated red corpuscles are present.

January 8. Animal died. Trypanosomes swarmed in the blood just before death, and were as numerous as the red corpuscles.

The following table shows the result of the blood examinations :—

Date.	Trypanosomes.	Date.	Trypanosomes.	Date.	Trypanosomes.
1905.		1905.		1906.	
Oct. 26 ...	—	Dec. 28 ...	+ +	Jan. 2 ...	+ +
Nov. 7 ...	—	„ 29 ...	+ +	„ 3 ...	+ +
„ 22 ...	—	„ 30 ...	+ +	„ 4 ...	+ +
„ 28 ...	+	„ 31 ...	+ +	„ 5 ...	+ +
Dec. 5 ...	+			„ 6 ...	+ +
„ 12 ...	+	1906.		„ 7 ...	+ + +
„ 20 ...	+	Jan. 1 ...	+ +	„ 8 ...	+ + +
„ 27 ...	+ +				

January 8. A *post-mortem* examination was made at death. Animal is thin, but not emaciated. Trypanosomes very numerous in the peripheral blood. Superficial lymphatic glands enlarged. Abdominal and mesenteric glands enlarged. Lungs and heart appear normal. Spleen enormously enlarged. Weight 4·35 grammes. Length 6·5 centimetres. Breadth 1·3 centimetres. Liver considerably enlarged; weight 12 grammes. Kidneys appear normal. Urine in bladder normal. Brain and spinal cord appear normal. Smears of the brain, when a brain capillary is seen in the smear, show the capillary swarming with trypanosomes. Smears of spleen show trypanosomes in very large numbers.

No. 512. Rat (Black and White). Female. Two cuts in each Ear.

October 26, 1905. Inject subcutaneously a few drops of an emulsion in normal citrate of the brain of rat 453 (*b*).

November 7. Trypanosomes have appeared in the blood to-day.

January 8, 1906. Trypanosomes have several times been numerous in the blood. Animal is apparently in good health. There are no symptoms of paralysis.

The following table shows the result of the blood examinations :—

Date.	Trypanosomes.	Date.	Trypanosomes.	Date.	Trypanosomes.
1905.		1905.		1906.	
Oct. 26 ...	—	Dec. 12 ...	—	Jan. 2 ...	+
Nov. 7 ...	+	„ 20 ...	+	„ 3 ...	+
„ 12 ...	+	„ 27 ...	—	„ 4 ...	+
„ 22 ...	—	„ 29 ...	+	„ 5 ..	+
„ 28 ...	+	„ 30 ...	—	„ 7 ...	—
Dec. 5 ...	—	„ 31 ...	—	„ 8 ...	+

No. 514. Rat (White). Female.

October 26, 1905. Inject subcutaneously a few drops of the deposit left after centrifuging the blood, and emulsified viscera of rat 453 (*b*).

November 22. Trypanosomes have appeared in the blood to-day.

November 28. Trypanosomes have now become very numerous in the blood. Animal seems in good health.

November 30. Trypanosomes have become comparatively scanty in the blood.

January 8, 1906. Animal remains in good health. No symptoms of paralysis. Trypanosomes remain present in the blood in scanty numbers.

The following table shows the result of the blood examinations :—

Date.	Trypanosomes.	Date.	Trypanosomes.	Date.	Trypanosomes.
1905.		1905.		1906.	
Oct. 26 ...	—	Dec. 2 ...	+	Jan. 1 ...	—
Nov. 7 ...	—	„ 5 ...	+	„ 2 ...	+
„ 16 ...	—	„ 12 ...	+	„ 3 ...	+
„ 22 ...	+	„ 20 ...	—	„ 6 ...	+
„ 28 ...	+ +	„ 27 ...	+	„ 8 ...	+
„ 29 ...	+ +	„ 29 ...	—	„ 9 ...	+
„ 30 ...	+				

Class D.

No. 458. Rat (Black and White). Female. Right Ear cut.

July 17, 1905. Inject subcutaneously a few drops of blood, mixed with normal citrate, taken from Ladha Singh, a sepoy, whose blood contains trypanosomes in moderate numbers.

August 12. Trypanosomes have appeared in the animal's blood to-day in scanty numbers.

September 13. Trypanosomes have been present in the blood continuously for the last month. The parasites have always been quite scanty. Animal remains in good health.

January 9, 1906. Animal remains in good health. Trypanosomes have not been present in the blood since the middle of September.

The following table shows the result of the blood examinations :—

Date.	Trypanosomes.	Date.	Trypanosomes.	Date.	Trypanosomes.
1905.		1905.		1905.	
July 17 ...	—	Aug. 16 ...	+	Nov. 12 ...	—
„ 21 ...	—	„ 19 ...	+	„ 16 ...	—
„ 23 ...	—	„ 23 ...	—	„ 22 ...	—
„ 25 ...	—	„ 27 ...	+	„ 28 ...	—
„ 27 ...	—	Sept. 1 ...	+	Dec. 5 ...	—
„ 29 ...	—	„ 6 ...	+	„ 12 ...	—
„ 31 ...	—	„ 13 ...	+	„ 20 ...	—
Aug. 2 ...	—	„ 20 ...	—	„ 27 ...	—
„ 4 ...	—	„ 27 ...	—		
„ 6 ...	—	Oct. 4 ...	—	1906.	
„ 8 ...	—	„ 19 ...	—	Jan. 3 ...	—
„ 12 ...	+	Nov. 1 ...	—	„ 9 ...	—
„ 14 ...	+				

January 23. This rat has now developed paralysis of the hind limbs. Trypanosomes are not present in the blood.

No. 394. CHIMPANZEE.

March 1, 1905. Examine animal's blood. Trypanosomes are absent. Animal seems healthy. Glands not palpable. Remove 30 cubic centimetres of cerebro-spinal fluid from Zenabu (a well marked case of sleeping sickness), and inject it subcutaneously into the left fore-arm of the chimpanzee. An examination of a further 8 cubic centimetres of cerebro-spinal fluid show that trypanosomes are present in it in scanty numbers. The fluid was quite free from blood, and was sterile on cultivation.

March 18. Trypanosomes are present in the animal's blood to-day. They are normal in appearance and numerous. Animal still very savage.

April 7. Animal's condition remains unaltered. Temperature 101°. Still takes his food well. Trypanosomes numerous in the blood.

May 1. Temperature 102°. Animal is suffering from tape-worm. Blood contains a few nucleated red cells. Trypanosomes are present but scanty.

May 15. Condition remains good, but animal is slightly thinner than on arrival. There is some fulness under the eyes. No enlarged glands can be felt.

May 29. Animal sits a great deal with his hands to his head. Coat is looking ragged. Trypanosomes are present in the blood, but in very scanty numbers.

June 12. Temperature 103°. Trypanosomes are absent from the blood. A distinct fulness under the eyes.

June 24. Enlarged glands felt in the right axilla. Gland punctured; gland-juice contains actively motile trypanosomes in fair numbers. Trypanosomes are absent from the blood.

July 6. Animal is much weaker than formerly; trypanosomes are present in the gland-juice but cannot be found in a blood-film.

July 22. Animal very thin and sick. Appetite bad. Temperature 95°. Gland-juice contains numerous trypanosomes. Blood-film negative.

July 29. Animal is getting worse every day. Temperature 95°·4. There is no tremor. Marked emaciation.

August 8. Animal died to-day.

Post-mortem examination one hour after death. Body is very thin and wasted. There is marked general superficial glandular enlargement. Smears of the gland-juice show trypanosomes in scanty numbers.

Trypanosomes not present in the cerebro-spinal fluid. Surface of brain normal, no thickening of the membranes. Brain appears normal to the naked eye. Smears of brain-substance showed nothing noteworthy. Sections of (1) cortex, (2) basal ganglia, (3) pons, and (4) medulla, were made and examined, but showed none of the changes characteristic of death from sleeping sickness in men.

Lungs and heart, normal. Liver, large and fatty. Kidneys, pale and somewhat soft. Capsule strips normally. Spleen, normal ; weighs 4 ozs. Stomach, dilated ; surface of mucous membrane pale, but otherwise normal. Blood-films taken and examined after death, do not show the presence of trypanosomes. Smears of the gland-juice taken from the cervical and axillary glands after death are also negative.

The following table shows the results of the blood and gland examinations, &c.

Date.	Percentages.					Parasites in Glands.		Parasites in Blood.			In Cerebro-spinal Fluid.	
	Poly.	Small.	Large.	Eos.	Bas.	Strept.	Tryp.	Fil.	Mal.	Tryp.	Strept.	Tryp.
March 1	...	...	...	...	...	...	...	—	—	—	...	...
„ 18	37	50	8	5	...	...	...	+	—	+	...	...
April 7	...	...	...	...	...	...	...	—	—	+	...	...
May 1	36	50	11	3	...	...	...	+	—	+	...	...
„ 15	62	27	11	—	...	...	...	+	—	+	...	...
„ 29	59	37	4	—	...	...	...	+	—	+	...	...
June 12	...	...	...	...	...	...	...	—	—	—	...	...
„ 24	53	41	3	—	...	...	...	+	—	—	...	...
July 5	55	42	3	—	...	...	+	—	—	—	...	...
„ 12	33	60	7	—	...	...	+	+	—	—	...	...
„ 22	...	...	...	...	...	...	+	+	—	—	...	...
„ 29	...	...	...	...	...	...	+	+	—	—	...	...
Aug. 8	...	...	...	...	...	...	...	—	—	—	...	—

Unfortunately this animal died from the effects of captivity six months after inoculation. It is interesting to note, however, that enlargement of the lymphatic glands appeared three months after inoculation, and that trypanosomes could easily be found in the gland-juice when prolonged examination of blood-films proved negative.

VII.—*On the occurrence of* Trypanosoma Gambiense *in the Blood of Native Dogs in Uganda.*

In Report No. VI., p. 275, where mention was made of an outbreak of sleeping sickness at Bugungu, at the north eastern extremity of the Albert Nyanza, it was also stated that the dogs of that district were said to be suffering from some wasting disease and that trypanosomes had been found in one of these animals. Dr. Pooley, the medical officer of the district, kindly obtained two of these native dogs for us, and had them forwarded to Entebbe, where they arrived on November 28, 1904. Both of them then presented a similar appearance. They were decidedly thin, their coats were rough and dirty and full of fleas. One of them showed some slight glandular enlargement in the axilla. There was no œdema or swelling of any part of their bodies. The ears of both animals were ragged and covered with scabs. Both dogs could run and walk normally and devoured their food eagerly. Their eyes were normal.

EXPERIMENT No. 332. DOG (NATIVE). MALE.

November 28, 1904. Blood examined; trypanosomes absent, no other parasite seen ; temperature 102°.

December 13. Blood again examined, nothing found. Animal very anæmic, and getting thinner. Segments of tape-worm found in motions.

January 5, 1905. Trypanosomes found in blood to-day in moderate numbers. This trypanosome in size and shape is practically identical with that of sleeping sickness in the blood of human beings.

January 12. Animal now very weak and ill and does not eat his food well. Trypanosomes cannot be found in the blood to-day.

January 17. Trypanosomes again present in the blood. There is no œdema or swelling in any part of the body. Eyes normal. Animal is extremely anæmic.

January 25. Animal died to-day.

The following tables shows the result of the blood examinations :—

Date.	Parasites in Blood.	Parasites in Cerebro-spinal Fluid.	Date.	Parasites in Blood.	Parasites in Cerebro-spinal Fluid.
	Trypanosomes.	Trypanosomes.		Trypanosomes.	Trypanosomes.
1904.			1905.		
Nov. 28 ...	—	...	Jan. 9 ...	—	...
Dec. 6 ...	—	...	,, 10 ...	—	...
,, 13 ...	—	...	,, 14 ...	—	...
			,, 17 ...	+	...
1905.			,, 24 ...	+	—
Jan. 5 ...	+	...			

Post-mortem examination (immediately after death). The body is extremely emaciated, abdomen retracted, whole carcase is covered with fleas and there are many ticks on the ears. Mucous membranes very anæmic. Eyes normal. No œdema. Lymphatic glands in axillæ and groin slightly enlarged, but not abnormal on section. Subcutaneous tissue normal.

On opening abdomen and thorax, both cavities are found to be free of fluid. Pericardium is normal. Heart, very anæmic, otherwise normal. Lungs, healthy. Spleen, not enlarged, normal on section. Kidneys, capsules strip off readily, very pale. Stomach and intestines show many small, white, thread-like worms in stomach and duodenum—Ankylostoma. Intestines are swarming with *Tænia solium* ; mucous membrane very pale.

Death was probably due to ankylostomiasis in this animal. Trypanosomes were only found occasionally in the blood, and never in large numbers.

Experiment No. 333. Dog (Native). Male.

November 28, 1904. Blood examined, nothing abnormal found.

January 5, 1905. Animal intensely anæmic and emaciated. Eyes normal No œdema or swelling of any part of the body. Animal can still walk and even run when urged.

January 15. Trypanosomes found in the blood to-day for the first time in scanty numbers. The parasite exactly resembles that found in a dog (Experiment No. 332) about ten days ago.

January 24. Animal died to-day. He has been getting steadily thinner and weaker, but there have been no other symptoms. For the last two days he has refused his food.

The following table gives the result of the blood examinations:—

Date.	Parasites in Blood.		Parasites in Cerebro-spinal Fluid.	Date.	Parasites in Blood.		Parasites in Cerebro-spinal Fluid.
	Pyrosomes.	Trypanosomes.	Trypanosomes.		Pyrosomes.	Trypanosomes.	Trypanosomes.
1904.				1905.			
Nov. 28	—	—	...	Jan. 10	—	—	...
Dec. 6	—	—	...	„ 15	—	+	...
„ 13	—	—	...	„ 20	—	—	...
				„ 24	—	+	—
1905.							
Jan. 5	—	—	...				

Post-mortem examination made a few minutes after death. A blood-film contains trypanosomes in moderate numbers. Emaciation very marked. Eyes normal. No swelling or œdema of any part of the body. Lymphatic glands not enlarged. Subcutaneous tissue normal. Pericardium, normal. Heart, very pale. Cavities somewhat dilated. Lungs show a few small areas of collapse, very pale. Spleen not enlarged, normal on section. Kidneys, normal. Stomach and intestines swarming with worms. Ankylostoma and *Tænia solium*. Brain showed nothing abnormal.

Death in this animal was almost certainly due to anæmia from the swarms of Ankylostoma present.

Evidence that the trypanosome found in the native Dogs from Bugungu is identical with the Trypanosoma Gambiense *of Sleeping Sickness.*

The trypanosome found in the two dogs sent to us from Bugungu is morphologically indistinguishable from the human parasite of sleeping sickness. In the original dogs sent to us the disease must have lasted at least three months, if, as it is only reasonable to suppose, these animals were already infected when they started on their journey to Entebbe. These two dogs presented none of the recognised symptoms of Nagana, such as swelling and œdema of the extremities, opacity of the cornea, or skin-eruption. At their death, rather more than three months after leaving Bugungu, they were thin, anæmic, and swarming with intestinal worms. While they were at Entebbe, trypanosomes could only rarely be found in a drop of their blood. On examining the animals after death, trypanosomes were numerous in the blood of both of them, but with no gland-enlargement, subcutaneous infiltration, or jelly-like deposit on the pericardium. In neither case was the spleen enlarged.

Injection experiments with this trypanosome on other animals have given the following results :—

A donkey, a bullock, and two goats have never shown trypanosomes in their blood since their inoculation six months ago. These animals are still apparently in good health.

A dog inoculated in July, 1905, died at the end of January, 1906 ; seven months after infection trypanosomes were always present in his blood, generally in considerable numbers.

Two cats inoculated in July are also alive and apparently healthy, although their blood constantly shows the presence of parasites. Two monkeys lived four and five months respectively after infection with this trypanosome. Their blood generally showed the presence of the parasite.

Two out of the three guinea-pigs inoculated with this trypanosome showed the parasite 19 days afterwards. One animal, which lived nine months, always showed the parasite in considerable numbers in its blood. The other animal died on its way to England. Of four rats inoculated with this parasite, one has died with paralysis of the hind limbs, and with trypanosomes numerous in the brain and spinal cord, but scanty in the blood, four months after infection. The other three rats have all quite occasionally shown the parasite in their blood. They seem at present in good health.

From these experiments it may be inferred that the trypanosome found in the dogs sent to us from Bugungu is really the trypanosome of sleeping sickness. This disease, at the time when these dogs were sent to us, had already broken out at Bugungu, and now, after a year's interval, has there assumed serious proportions. That the tsetse fly bites dogs is a fact well known to anyone who has taken a dog into a fly-infested area. Whether dogs infected with the trypanosome of sleeping sickness actually die from such infection does not at present seem clear. The two original dogs from Bugungu certainly died in our laboratory within a few days of one another, but they were very anæmic from swarms of intestinal parasites (Ankylostoma, Tænia, &c.). A healthy dog inoculated from one of them has just died, seven months after infection ; trypanosomes were constantly present in his blood. Dogs inoculated with the trypanosome of sleeping sickness by former members of this Commission, and kept in this laboratory, all died of ankylostomiasis, and in no single case was death attributed to their trypanosomes.

It seems then, that in areas of sleeping sickness dogs as well as men may act as carriers of the disease. The fact that infected dogs may live a long while, and, as a rule, show the parasite in their peripheral blood in far greater numbers than is the case with human beings, makes them of considerable importance as a source of infection in districts infested with flies.

As the question of the identity of this "Bugungu" trypanosome with *Trypanosoma gambiense* appears to us to be of considerable importance, we give in detail the results of inoculation experiments performed by us with it.

Experiment No. 209 (*a*). Ox (fawn).

January 24, 1905. Injected subcutaneously 10 cubic centimetres of blood from dog, Experiment No. 333, containing trypanosomes in moderate numbers.

April 27. This animal's blood has been regularly examined every week up to now, but trypanosomes have never been found in it. The animal remains in good health.

August 1. Animal still in good health. Trypanosomes have never appeared in its blood.

Experiment No. 296 (*a*). Goat (black and white).

January 25, 1905. Injected subcutaneously 5 cubic centimetres of blood from dog Experiment No. 332, containing trypanosomes in scanty numbers.

April 27. Animal remains in good health. Its blood has been regularly examined every week up to now, but trypanosomes have never been found therein.

Experiment No. 305 (*a*). Donkey. Top off Right Ear.

January 24, 1905. Injected subcutaneously 10 cubic centimetres of blood from dog, Experiment No. 333, containing trypanosomes in moderate numbers.

April 27. This animal remains in good health. Its blood has been examined every week, but trypanosomes have never been found in it.

Experiment No. 371. Guinea-pig.

January 24, 1905. Injected subcutaneously 1 cubic centimetre of blood, mixed with citrate, from dog, No. 332, containing numerous actively motile trypanosomes.

March 28. Trypanosomes have not appeared in the animal's blood since inoculation. Re-inoculate animal by injecting a few drops of blood from guinea-pig, No. 372, containing the "Bugungu" trypanosomes in moderate numbers.

April 17. Trypanosomes have appeared in the blood to-day for the first time, 20 days after re-inoculation. The parasites are short, blunt pointed, and closely resemble the sleeping sickness trypanosome.

September 10. Up to to-day this animal has apparently been in good health; to-day it was found dead.

The following table shows the presence or absence of trypanosomes in the blood:—

Date.	Trypanosomes.	Date.	Trypanosomes.	Date.	Trypanosomes.
1905.		1905.		1905.	
Jan. 27 ...	—	April 17 ...	+	June 29 ...	+
Feb. 1 ...	—	„ 27 ...	+	July 11 ...	+
„ 17 ...	—	May 13 ...	+	„ 23 ...	+
„ 24 ...	—	„ 27 ...	+	„ 28 ...	+
March 18 ...	—	June 8 ...	+	Aug. 12 ...	+
„ 28 ...	—	„ 18 ...	+	„ 24 ...	+
April 4 ...	—	„ 24 ...	+	Sept. 4 ...	+

Post-mortem examination. Animal not emaciated. Eyes normal. Stomach and intestines full of food. All viscera appear normal. Spleen slightly enlarged. Trypanosomes could not be found in the blood. Lymphatic glands not enlarged.

EXPERIMENT No. 351. MONKEY (*Cercopithecus sp.*).

March 28, 1905. Animal's temperature has been taken every day for the last month, and has been found to be normal. Frequent blood-examinations have proved the absence of trypanosomes. Inoculate the monkey with "Bugungu" trypanosomes by injecting under the skin a few drops of blood from guinea-pig, No. 372.

April 6. Trypanosomes are present in the blood to-day for the first time. Animal's temperature is 105·4°.

May 14. Temperature irregular, varying between 99° and 103°. Trypanosomes have been constantly present in the blood since the first infection.

June 30. Animal has got progressively thinner and weaker. The eyes are normal, there are no enlarged superficial glands or œdema.

July 19. Animal died to-day.

The following table shows the result of the blood examinations in this case :—

Date.	Parasites in Blood.		Parasites in Cerebro-spinal fluid.		Date.	Parasites in Blood.		Parasites in Cerebro spinal-fluid.	
	Mal.	Tryp.	Strept.	Tryp.		Mal.	Tryp.	Strept.	Tryp.
1905.					1905.				
March 28 ...	+	—	...	...	May 21 ...	+	+	...	...
April 1 ...	+	—	...	...	" 30 ...	+	—	...	...
" 6 ...	+	+	...	...	June 8 ...	+	+	...	...
" 15 ...	+	+	...	...	" 18 ...	+	—	...	...
" 21 ...	+	+	...	...	" 26 ...	+	+	...	...
" 28 ...	+	+	...	...	July 7 ...	+	+	...	...
May 4 ...	+	+	...	...	" 14 ...	+	+	...	...
" 14 ...	+	+	...	...	" 19 ...	...	+	...	—

Post-mortem made at death. Animal is thin. Pupils equal and normal. Superficial lymphatic glands not enlarged. On reflecting the dura mater, the surface of the cortex appears normal. Trypanosomes are not present in the cerebro-spinal fluid. Portions of brain are removed for minute examination. Heart appears normal. There is a little free fluid in the pericardial cavity. A drop of heart's blood contains trypanosomes in moderate numbers. The rest of the viscera appear normal. Spleen is enlarged to about twice the normal size.

The course of this Bugungu disease in a monkey very closely resembles that of sleeping sickness in the same animal. Trypanosomes were always present in the animal's blood, but never in large numbers.

EXPERIMENT No. 446. DOG (WHITE AND BROWN).

July 12, 1905. Injected subcutaneously a few drops of blood from monkey No. 351 containing the "Bugungu" trypanosome in scanty numbers.

August 4. Trypanosomes have appeared in the animal's blood to-day.

October 9. Animal remains in good health. Trypanosomes are constantly present in the blood. Many short stumpy forms of the parasite seen.

January 9th 1906. Animal does not seem quite so well as formerly. Appetite not good ; he seems drowsy and listless and has lost flesh considerably. There is loss of power especially in the hind limbs Eyes normal. Cervical lymphatic glands distinctly enlarged.

January 15. Animal remains in much the same state but is getting gradually weaker. He is always lying down and is apparently too weak to stand for long. Trypanosomes have always been seen in the blood ever since they first appeared, but never until lately in anything but scanty numbers. Glandular enlargement well-marked.

The following table shows the result of the blood-examinations :—

Date.	Parasites in Blood.			Date.	Parasites in Blood.		
	Pyro.	Mal.	Tryp.		Pyro.	Mal.	Tryp.
1905.				1905.			
July 12 ...	—	...	—	Dec. 6 ...	—	...	+
„ 24 ...	—	...	—				
August 4 ...	—	...	+	1906.			
Sept. 6 ...	—	...	+	Jan. 9 ...	—	...	+
Oct. 9 ...	—	...	+	„ 15 ...	—	...	+
Nov. 4 ...	—	...	+	„ 20 ...	—	...	+

January 28. Animal moribund. Killed with chloroform.

Post-mortem examination at death. Heart and lungs normal. Spleen enlarged, soft and congested, weighs 4 ozs. Kidneys normal. Liver normal. All the glands of the body enlarged, both superficial, deep, abdominal and mesenteric. A blood-film taken after death did not show trypanosomes although a Filaria about the same size as *Filaria perstans*, but with a sharply pointed caudal extremity, was present. This Filaria seems similar to that found formerly in the blood of monkeys and described in the last Report. No traces of an adult Filaria could be found. Brain appeared normal to the naked eye. Cerebro-spinal fluid not increased. Trypanosomes were numerous in the deposit left after centrifuging some blood stained cerebro-spinal fluid. Emulsions of portions of the brain in normal citrate-solution showed trypanosomes to be present in scanty numbers. Sections of the brain, stained by Leishman's method, showed well-marked small-celled infiltration around the blood vessels. This change was more marked in the deeper parts of the brain-substance than in the cortex. (*See* plate I.)

EXPERIMENT NO. 461. CAT (TAME, BLACK AND WHITE).

July 19, 1905. Injected subcutaneously a few drops of blood from monkey No. 351 containing trypanosomes in scanty numbers.

August 14. Trypanosomes have appeared in the blood to-day for the first time.

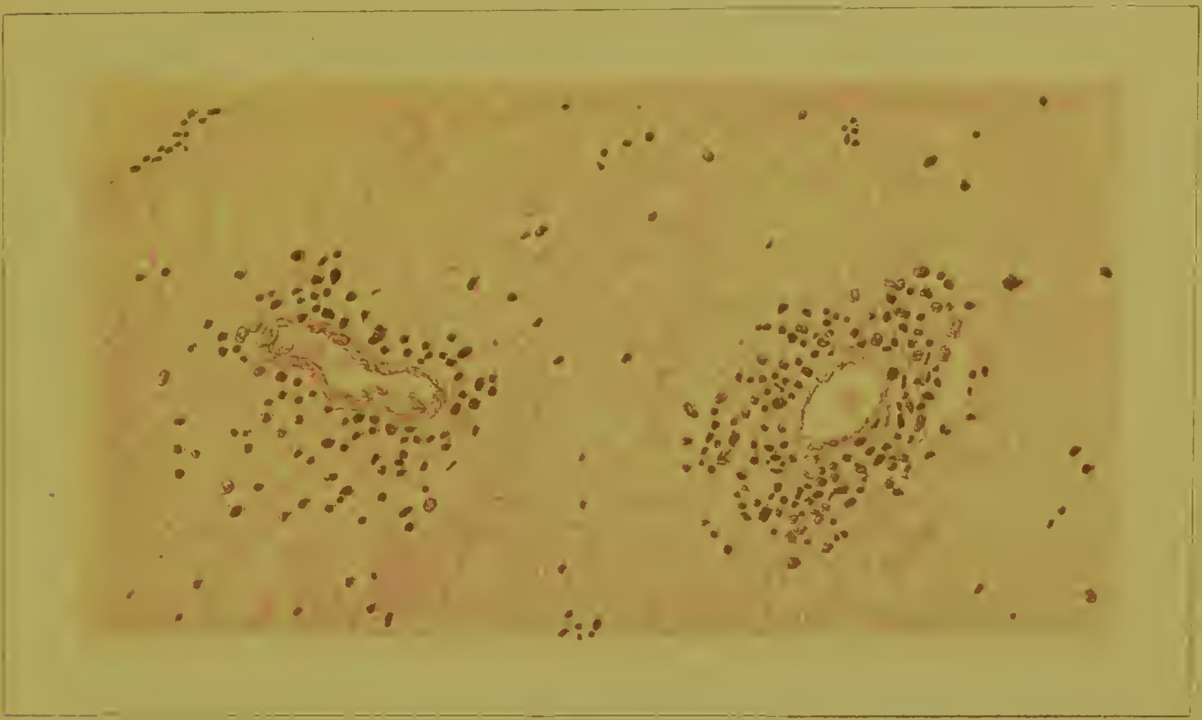
January 22, 1906. Animal remains in good health, trypanosomes have been present in the blood almost continually since their first appearance.

The following table shows the results of the blood examinations :—

Date.	Parasites in Blood.	Date.	Parasites in Blood.	Date.	Parasites in Blood.
	Trypanosomes.		Trypanosomes.		Trypanosomes.
1905.		1905.		1905.	
July 19 ...	—	Aug. 19 ...	+	Nov. 25 ...	+
„ 27 ...	—	„ 31 ...	+	Dec. 10 ...	+
„ 30 ...	—	Sept. 11 ...	+	„ 27 ...	+
Aug. 2 ...	—	„ 20 ...	—		
„ 4 ...	—	„ 27 ...	+	1906.	
„ 6 ...	—	Oct. 7 ...	+	Jan. 8 ...	+
„ 10 ...	-	„ 20 ...	—	„ 22 ...	+
„ 14 ...	+	Nov. 1 ...	—		

SECTION OF BASAL GANGLIA OF BRAIN OF DOG N° 446, SHOWING MARKED SMALL-CELLED INFILTRATION AROUND THE BLOOD VESSELS. THIS DOG WAS INOCULATED WITH THE "BUGUNGU" STRAIN TO TRYPANOSOME AND DIED SEVEN MONTHS AFTER INFECTION.

(Drawn with camera lucida from a section stained by Leishman's method Zeiss 16 mm Apochromatic obj. N° 8 comp. ocular).



EXPERIMENT No. 454. RAT (BLACK AND WHITE).

July 17, 1905. Injected a few drops of blood, mixed with normal citrate solution, from guinea-pig No. 371 (Bugungu) into this rat.

July 27. Trypanosomes first appeared in this animal's blood to-day. They are very scanty in number.

October 24. There is some weakness of the animal's hind limbs to-day. Trypanosomes have not been found in the blood since August 4.

November 1. There is very marked paralysis of both hind limbs. Except for this the animal seems fairly well.

November 15. Animal died this morning. The paralysis never spread beyond the hind limbs. During the last few days the animal's coat became very dirty and lousy.

The following table shows the result of the blood examinations :—

Date.	Trypanosomes.	Date.	Trypanosomes.	Date.	Trypanosomes.
1905.		1905.		1905.	
July 20 ...	—	Aug. 6 ...	—	Sept. 20 ...	—
„ 21 ...	—	„ 8 ...	—	„ 27 ...	—
„ 23 ...	—	„ 14 ...	—	Oct. 4 ...	—
„ 24 ...	—	„ 19 ...	—	„ 17 ...	—
„ 25 ...	—	„ 21 ...	—	„ 19 ...	—
„ 27 ...	+	„ 23 ...	—	„ 24 ...	—
„ 29 ...	+	„ 27 ...	—	Nov. 1 ...	—
„ 31 ...	+	Sept. 1 ...	—	„ 12 ...	—
Aug. 2 ...	+	„ 6 ...	—	„ 15 ...	—
„ 4 ...	+	„ 13 ...	—		

Post-mortem. Examination made about three hours after death. Animal is emaciated; covered with lice. Eyes appear normal. No marked enlargement of the superficial lymphatic glands. The brain and spinal cord appear normal to the naked eye. An emulsion of brain-matter in normal citrate-solution shows numerous trypanosomes even without centrifuging. Stained films of this emulsion show vacuolated trypanosomes in large numbers. Similar emulsions of the spinal cord show trypanosomes in scanty numbers. The superficial lymphatic glands are slightly enlarged. The spleen and other viscera appear quite normal. Trypanosomes are not present in a blood-film, but have been found in very scanty numbers after centrifuging the heart's blood. Sections of brain stained by Leishman's method show numerous trypanosomes all through the brain-substance. Trypanosomes have not been seen in the blood-vessels of the brain. A small-celled infiltration is evident around these blood-vessels, more marked in the deeper parts than in the brain-cortex.

The course of the disease, the subsequent paralysis, the *post-mortem* appearances and the aspect of the sections of the brain in this animal are in every way similar to what we have found in rats infected with the trypanosome of sleeping sickness. Apart from other evidence, this experiment shows that the Bugungu trypanosome is identical with the trypanosome of sleeping sickness.

VIII.—*The Trypanosome of the Jinja cattle disease. Further inoculation experiments on White Rats, Guinea-pigs, &c. Effect of Drugs on animals inoculated with this parasite.*

In Report No. VI., p. 11, a good deal of information was given concerning a disease which had proved very fatal to a large herd of cattle in Usoga. This disease was found to be due to the presence of a trypanosome in the blood of these cattle, and from experimental inoculations with this trypanosome on a number of different animals it seemed likely that this trypanosome was either identical with *Trypanosoma Brucei* or else a very closely allied species.

In the following tables we give the results of some further inoculation experiments which we have conducted on white rats and guinea-pigs.

WHITE RATS.—Incubation period: shortest, 4 days; longest, 8 days; average, 5 days. Total length of the disease from day of inoculation to day of death: shortest, 10 days; longest, 29 days; average, 20 days.

Course of the disease.—Trypanosomes appear scantily in the blood about the fifth day, and from this time forward, as a rule, the parasites become more and more numerous until at death they outnumber the red blood corpuscles. Sometimes we have noticed that early in the disease at about the 10th to the 15th day the parasites temporarily disappear from the blood-stream, but that in such cases the trypanosomes always reappear again, and that then the disease runs its normal course. Three of these rats showed exhibited well-marked corneal opacity which appears within a few days of death. Two of them showed paralysis of the hind limbs within a day or two of death. As a rule, the rats seemed in good health up to 48 hours of death. Death occurred somewhat suddenly and was accompanied by convulsive movements, and the appearance of blood-stained froth around the mouth.

The *post-mortem* appearances were very constant. Hæmorrhages into the substance of both the lungs were present in every case, sometimes extensively. There was no enlargement of the lymphatic glands. The spleen was considerably enlarged in every case. The heart appeared quite normal. In many cases the bladder contained blood-stained urine, and in these cases the kidneys were hæmorrhagic.

GUINEA-PIGS.—Incubation period: shortest, 6 days; longest, 19 days; average, 9 days. Total length of the disease: longest, 93 days; shortest, 9 days; average, 35 days.

Course of the disease.—Trypanosomes having once appeared in the animal's blood could in every case be found there till death. Parasites were always numerous in the blood and at death were invariably present in large numbers. Two of these animals showed paralysis of the hind quarters shortly before death. Opacity of the cornea was not observed in any instance. As in the case of white rats, death often seemed to occur very suddenly.

The *post-mortem* appearances consisted of hæmorrhages into the lungs in several cases. Petechiæ over the surface of the heart were often noticed ; in one case there was marked pericardial effusion. The spleen was always enlarged and generally to a considerable extent. The superficial lymphatic glands were sometimes slightly enlarged.

TABLE X.

White Rats inoculated with the Trypanosome of the Jinja cattle disease.

No. of Experiment.	Date of Inoculation.	Date of appearance in Peripheral Blood.	Result.
444	July 2 ...	July 6 ...	Died July 29. (27 days.) Large spleen. Trypanosomes swarming in the blood. Lungs full of hæmorrhages. Urine blood stained.
467	Aug. 10 ...	Aug. 16 ...	Died Sept. 8. (29 days.) Autopsy as above.
469	,, 25 ...	,, 31 ...	Died Sept. 11. (17 days.) Autopsy as above, but liver also enlarged. Lymphatic glands somewhat enlarged.
475	Sept. 8 ...	Sept. 12 ...	Died Sept. 24. (16 days.) Autopsy as above.
476	, 11 ...	,, 19 ...	Died Sept. 28. (17 days.) Autopsy as above.
483	,, 20 ...	...	Died Oct. 15. (25 days.) Autopsy as above, with opacity of both corneæ.
484	,, 20 ...	...	Died Oct. 15. (25 days.) Autopsy as above. Urine normal.
485	,, 20 ...	...	Died Oct. 7. (17 days.) Autopsy as above. Eyes normal.
486	,, 25 ...	Sept. 29 ...	Died Oct. 10. (15 days.) Animal showed paralysis of the hind limbs for a day or two before death. Autopsy as before.
487	,, 28 ...	Oct. 5 ...	Died Oct. 19. (21 days.) Showed paralysis of hinder extremities before death. Trypanosomes swarmed in the blood at death. Spleen very large. Glands slightly enlarged. Lungs show numerous hæmorrhages. Eyes normal. Urine not blood-stained.
495	Oct. 4 ...	,, 9 ...	Died Oct. 29. (25 days.) Autopsy as above. Opacity of right cornea. No paralysis before death.
501	,, 7 ...	,, 12 ...	Died Oct. 30. (23 days.) Autopsy. Eyes normal, otherwise as above. No paralysis.
515	,, 29 ...	...	Died Nov. 8. (10 days.) Autopsy as above. Liver also larger than normal. Urine blood stained. Eyes normal. No paralysis.

TABLE XI.

Guinea-pigs inoculated with the Trypanosome of the Jinja cattle disease.

No. of Experiment.	Date of Inoculation.	Date of appearance in Peripheral Blood.	Result.
329	Nov. 22...	Nov. 29 ... (7 days.)	Died on Dec. 24. Swarming with parasites. Hæmorrhages into lungs. Spleen slightly enlarged.
338	Dec. 4...	Dec. 14 ... (10 days.)	Died Jan. 7, as above.
337	„ 4...	Dec. 14 ... (10 days.)	„ „ 25 „
366	Jan. 12...	Jan. 20 ... (8 days.)	„ „ 27 „
367	„ 12...	Jan. 20 ... (8 days.)	„ Feb. 9 „
388	March 28...	April 4 ... (7 days.)	„ May 7 „
400	April 15...	April 27 ... (12 days.)	Died July 29. Paralysis of hind limbs. Trypanosomes swarming in the blood. Spleen much enlarged.
401	„ 15...	May 3 ... (18 days.)	Died May 28. Paresis of hind quarters. Spleen only slightly enlarged. Lungs hæmorrhagic.
402	May 7...	May 13 ... (6 days.)	Died June 12. Swarming with trypanosomes. Spleen slightly enlarged. Lungs hæmorrhagic.
426	June 18...	July 1 ... (13 days.)	Died July 19. Spleen enlarged. Trypanosomes very numerous.
427	„ 18...	June 24 ... (6 days.)	Died July 6. Spleen slightly enlarged. Trypanosomes very numerous.
435	„ 24...	July 1 ... (7 days.)	Died July 3. Spleen not enlarged. Trypanosomes very numerous.
465	July 29...	Aug. 6 ... (8 days.)	Died August 25. Spleen slightly enlarged. Trypanosomes very numerous.
488	Sept 28...	Oct. 9 ... (11 days.)	Died November 5. Spleen enlarged.

MONKEYS.—Incubation period: shortest, 4 days; longest, 10 days; average, 6 days.

Total length of the disease from day of inoculation to day of death: shortest, 28 days; longest, 86 days; average, 56 days.

Course of the disease.—The appearance of the trypanosomes in the blood about the sixth day is marked by a sharp rise of temperature. Trypanosomes are always to be found in the blood from this time onwards, and are often numerous. For the first month or so the temperature chart shows sharp elevations every few days. About a month before death marked daily variations of temperature begin to occur, and become more and more marked. Trypanosomes are numerous in the blood at death. We have never observed any symptoms of paralysis or eye changes in such monkeys.

On *post-mortem* examination the lungs often show small hæmorrhages, petechial hæmorrhages are found on the heart, the abdominal lymphatic glands are generally enlarged, the liver was often found to be fatty, and the spleen was always considerably larger than normal.

The following table shows the results of inoculating six monkeys with this trypanosome :—

TABLE XII.

Monkeys Inoculated with the "Jinja" Cattle Trypanosomes.

No. of Animal.	Date of Inoculation.	Date of appearance in Blood.	Result.
317	Sept. 4 ...	Sept. 11 ...	Died Nov. 22. Trypanosomes always numerous in blood. Spleen and abdominal glands enlarged. Petechial hæmorrhages in lungs, heart, and stomach.
322	Oct. 26 ...	Nov. 1 ...	Died Nov. 23. Trypanosomes always numerous. Spleen somewhat enlarged. Other viscera very anæmic.
344	Dec. 11 ...	Dec. 16 ...	Died Jan. 12. Trypanosomes always numerous. Spleen enlarged. Liver shows points of pus all through its substance. Small abscess size of cherry between liver and right kidney. Mesenteric glands enlarged.
384	Feb. 22 ...	March 4 ...	Died May 19. Trypanosomes always very numerous. Organs anæmic. Petechiæ on heart. Spleen markedly enlarged.
335	Dec. 4 ...	Dec. 16 ...	Died Jan. 25. Trypanosomes always present in the blood.
330	Nov. 23 ...	Nov. 27 ...	A large dose of arsenic caused trypanosomes to disappear, and cured the animal.

The effect of Drugs upon Monkeys suffering from the "Jinja" Cattle Trypanosome.

We have already shown that the "Jinja" cattle trypanosome is always fatal to monkeys, and that during the course of the disease in these animals the trypanosomes are constantly present in the animal's blood in considerable numbers. We have tried arsenic and trypanroth on a few monkeys infected with this trypanosome with the view of ascertaining whether these drugs can in any way modify the course of the disease.

Arsenic.—(1.) As a curative agent. We have tried this drug on two monkeys infected with this trypanosome. In the first case a maximum dose of arsenic was injected into the animal four days after the trypanosomes had first appeared in the blood, with the result that the animal was cured and was well 4½ months after the arsenic had been given, trypanosomes never having reappeared in the blood. A second infected monkey was given a similar dose of arsenic after trypanosomes had been present in the animal's blood for 12 days, but in this case the parasites reappeared in the blood, and the animal died 2½ months after infection.

(2.) As a prophylactic. We found arsenic quite useless in this respect. A maximum dose of it given 24 hours before inoculating the animal with this trypanosome only doubled the length of the incubation period of the disease.

Trypanroth.—A maximum dose of this drug injected into a monkey infected with this trypanosome had the effect of causing the parasites to disappear for four days only. The disease ran its usual fatal course.

A monkey was inoculated with this trypanosome 48 hours after it had been given a maximum dose of trypanroth. This previous dose of trypanroth had no power to protect the animal against the disease; trypanosomes appeared in the blood at the usual time, and the disease terminated fatally as usual.

EXPERIMENT NO. 330. MONKEY (*Cercopithecus sp.*). WEIGHT, 4·98 KILOGRAMMES.

November 23. Inject one cubic centimetre of blood containing trypanosomes from the heart of monkey 317, obtained *post-mortem*. (Monkey 317 died in three months from the "Jinja" cattle disease.)

November 27. Trypanosomes present in the blood to-day. Temperature 107°.

November 30. Trypanosomes present in the blood in very large numbers. Temperature 106°. Inject arsenic 12 milligrammes, equivalent to 1 milligramme per 400 grammes monkey. Animal's blood examined 2½ hours after the injection. No living trypanosomes can be found in the blood. A blood-film shows a very few parasites. 4.30 p.m. (seven hours after the arsenic); temperature 101°. Blood examined; trypanosomes absent. Animal sits in a doubled-up posture, refuses food.

December 1. Animal still seems sick. Diarrhœa present. Marked thirst, refuses food. Trypanosomes absent from a blood-film.

December 5. Animal seems to have recovered from the arsenic. Trypanosomes absent from blood.

March 1. Animal's blood has been examined regularly once a week for the last three months. Trypanosomes have never been found. Animal is thin, but otherwise is in good health. The temperature has remained generally about normal.

April 6. Trypanosomes have now been absent from the blood for more than four months. Animal is getting very thin and beginning to show a swinging temperature. Reinject 1 cubic centimetre of blood taken from monkey 384 containing the "Jinja" trypanosome in large numbers.

April 14. Trypanosomes have again appeared in the blood to-day, eight days after the second inoculation.

April 16. Animal very sick, lies on its side, eats very little.

The following table shows the presence or absence of trypanosomes in the blood :—

Date.	Parasites in Blood.		As_2O_3. 12 Milli-grammes.	Date.	Parasites in Blood.		As_2O_3. 12 Milli-grammes.
	Mal.	Tryp.			Mal.	Tryp.	
Nov. 25 ...	+	—	...	Jan. 6 ...	+	—	...
„ 27 ...	+	+	...	„ 17 ...	+	—	...
„ 30 ...	+	+	12	„ 24 ...	+	—	...
(10 a.m.)				„ 30 ...	+	—	...
Nov. 30 ...	+	—	...	Feb. 8 ...	+	—	...
(12 noon.)				„ 14 ...	+	—	...
Dec. 1 ..	+	—	...	„ 21 ...	+	—	...
„ 7 ...	+	—	...	March 1 ...	+	—	...
„ 11 ...	+	—	...	„ 8 ...	+	—	...
„ 18 ...	+	—	...	„ 17 ...	...	—	...
„ 23 ...	+	—	...	„ 28 ...	...	—	...
„ 30 ..	+	—	...	April 6 ...	...	—	(reinoculated).
				„ 14 ...	...	+	...

EXPERIMENT No. 361. MONKEY (*Cercopithecus sp.*).

To note the effect of a single large dose of arsenic on a monkey infected with the trypanosome of the "Jinja" cattle disease.

March 18. Weight of monkey 2·381 kilogrammes. Blood examined and found to contain malaria but no other parasite.

March 28. Animal's temperature has been taken night and morning for the last ten days and has been found to be normal. Inoculate monkey with the "Jinja" trypanosome, by injecting a few drops of blood from monkey 384, in which the parasites are active and numerous.

April 3. Temperature has suddenly run up to 108°. Trypanosomes are numerous in the blood to-day, six days after inoculation.

April 15. Trypanosomes have now been constantly present in the blood for ten days. Give arsenic 6 milligrammes, equivalent to 1 milligramme arsenic per 400 grammes monkey. Trypanosomes disappeared from the blood in 2½ hours.

April 16. Animal not much the worse for the arsenic.

May 3. Trypanosomes have again appeared in the blood to-day (19 days after arsenic).

May 25. Animal died in the night, during a heavy storm. The monkey had been getting steadily thinner and showed a swinging temperature for the last fortnight.

The following table shows the result of the blood examinations :—

Date.	Parasites in Blood.			—
	Fil.	Mal.	Tryp.	
March 28	...	+	—	...
April 3	. .	+	+	...
„ 10	...	+	+	...
„ 15 (10 45 a.m.) ...	...	+	+	As_2O_3, 6 milligrammes.
„ „ (11.45 „) ...	...	+	+	...
„ „ (12.45 p.m.) ...	...	+	+	Trypanosomes very scanty.
„ „ (1.15 „) ...	...	+	—	...
„ 19	...	+	—	...
„ 21	...	+	—	...
„ 28	...	+	—	...
May 3	...	+	+	...
„ 5	...	+	+	...
„ 14	...	+	+	...
„ 25	...	...	+	Autopsy.

Autopsy made about eight hours after death. Trypanosomes numerous and active in the heart's blood. Animal thin. No glandular enlargement. Eyes normal. Spleen enlarged to about three times the normal size. Smears of spleen show numerous trypanosomes. Other organs apparently healthy.

It is interesting to compare this experiment with experiment 330. The two animals were given exactly similar doses of arsenic, viz., 1 milligramme of arsenic per 400 grammes weight of monkey. In experiment 330 the drug was given four days after the first appearance of the trypanosome in the blood, with the result that the animal was cured. In the present experiment the arsenic was given 12 days after the first appearance of the parasite, with the result that the trypanosomes only disappeared for a time, reappearing again 19 days after the drug had been administered.

EXPERIMENT NO. 335. MONKEY (*Cercopithecus sp.*). WEIGHT, 1·247 KILOGRAMMES.

To note the effect of arsenic as a prophylactic in the case of the "Jinja" trypanosomes.

December 3 (2 p.m.). Examine blood. Trypanosomes are absent. Malaria present. Give arsenic 5 milligrammes (equivalent to 1 milligramme arsenic per 250 grammes monkey).

December 4 (10 a.m.). Animal seems sick, has been much purged in the night. Inoculate it with "Jinja" trypanosome, by injecting a few drops of blood from guinea-pig 329, in which the parasites are very numerous.

December 16. Temperature 107°. Trypanosomes are present in the blood to-day for the first time (12 days after inoculation). Up to to-day, animal's blood had been examined every other day, but always with a negative result.

Date.	Parasites in Blood.		As_2O_3 in milligrammes.
	Mal.	Tryp.	
Dec. 3	...	—	5
„ 4	Inoculate with trypanosomes ("Jinja").		
„ 11	...	—	...
„ 16	...	+	...
„ 19	...	+	...

EXPERIMENT NO. 339. MONKEY (*Cercopithecus sp.*). WEIGHT, 1·460 KILOGRAMMES.

CONTROL ON EXPERIMENT 335.

December 4. Examine blood. Trypanosomes are absent. Malaria present. Inoculate monkey with "Jinja" trypanosome, by injecting a few drops of blood from guinea-pig 329, in which the parasites are very numerous.

December 7. Blood examined. Trypanosome absent. Malaria present.

December 8. Temperature 106·4°. Trypanosomes are present in the blood to-day for the first time (four days after inoculation).

Remarks.—The above experiments show that even a maximum dose of arsenic given to a monkey twenty hours before he is inoculated with the trypanosome of the "Jinja" cattle disease, is powerless to protect the animal against infection, although it has the effect of considerably lengthening the incubation period of the disease.

EXPERIMENT NO. 317. MONKEY (*Cercopithecus sp.*). WEIGHT, 1·5 KILOGRAMMES.

To note the effect of subcutaneous injection of a solution of trypanroth in a monkey suffering from the parasite of the "Jinja" cattle disease.

September 4. Examine blood-film. Trypanosomes are absent. Inoculate monkey with 1·5 cubic centimetre blood from monkey No. 315, containing numerous trypanosomes.

September 11. Trypanosomes are present in the blood to-day for the first time (seven days after inoculation). Temperature, 105·6°.

October 26. Trypanosomes have been constantly present in the animal's blood for the last six weeks. Injected 10 cubic centimetres of 1 per cent. solution of trypanroth at 12.30 p.m.

November 1. Trypanosomes have reappeared in the animal's blood to-day.

November 19. Animal died to-day. Trypanosomes have been present in the blood in increasing numbers since November 1.

The following table shows the result of the blood examinations and the result of this injection on the trypanosomes :—

Date.	Parasites in Blood.		No. of Trypanosomes per c. milli-gram.	Leucocytes per c. milli-gram.
	Mal.	Tryp.		
Sept. 9	—	—	...	...
„ 11	—	+	...	...
„ 15	—	+	...	...
„ 21	—	+	...	...
„ 22	—	+	...	...
„ 30	—	+	...	...
Oct. 7	—	+	...	...
„ 14	—	+	...	...
„ 21	—	+	...	...
„ 26	—	+	11,250	15,000
„ 27	...	+	400	40,600
„ 28	...	—	...	31,200
„ 29	...	—	...	29,600
„ 31	...	—	...	18,700
Nov. 1	...	+	30	12,000
„ 2	...	+	280	9,300
„ 4	...	+	1,020	17,000
„ 7	...	+	7,000	13,000
„ 14	...	+	...	...
„ 19	...	+	...	...

EXPERIMENT No. 320. MONKEY (*Cercopithecus sp.*). WEIGHT, 2·51 KILOGRAMMES.

To note the effect of trypanroth (Ehrlich) on a monkey, and further to note whether this drug has any prophylactic effect against infection with the "Jinja" cattle disease.

October 26. Inject subcutaneously 20 cubic centimetres of a 1 per cent. solution of trypanroth.

October 27. Animal shows some subcutaneous pigmentation. General health is good.

October 28. Subcutaneous pigmentation very marked indeed.

December 2. There is still a trace of pigmentation to be seen. The drug does not seem to have affected the animal's health in any way. Some thickening can be felt at the seat of inoculation. Inject subcutaneously a further dose of 25 cubic centimetres of 1 per cent. trypanroth.

December 4. There is very intense pigmentation present. Inoculate the animal with the "Jinja" trypanosome by injecting a few drops of blood from guinea pig 329, which contains trypanosomes in large numbers.

December 14. Trypanosomes are present in the animal's blood to-day. Animal's temperature has risen suddenly to 105·6°.

Remarks.—These two experiments show that a large single dose of trypanroth simply causes a very temporary disappearance of the parasites from the blood in the case of an animal infected with the trypanosome of the "Jinja" cattle disease, and that a similar large dose of trypanroth given 48 hours before inoculating an animal with this disease has no prophylactic effect.

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17. REPORT ON EXPERIMENTS TO ASCERTAIN THE ABILITY OF TSETSE FLIES TO CONVEY *TRYPANOSOMA GAMBIENSE* from Infected to Clean Monkeys, and on an Intra-Corpuscular Stage of the Trypanosoma.

BY PHILIP H. ROSS, M.R.C.S., L.R.C.P. LOND., D.P.H. (Camb.).

Between the months of July and December, 1904, two experiments were carried out, to see whether the Tsetse flies found near Kibwezi are able to convey the *Trypanosoma gambiense* from an infected to a clean monkey. The first of these experiments was made with *Glossina fusca*, the interval between feeding on infected and clean monkey being eight hours. The second experiment was with *Glossina pallidipes*, the interval in this case being 24 hours.

At first, before the experiments could be begun, continual delays arose from various causes, of which the most important and the one which led to the longest delay was the fact that all the monkeys sent me for experimental purposes were in various stages of Piroplasmosis. This has already been the subject of a note in the *Journal of Hygiene* (vol. V., No. 1, January, 1905). In all cases the monkeys were kept in fly-proof cages onwards from their arrival. When at last the temperature of the monkeys had become nearly normal experiments were started and were carried out in the following manner :—

The flies were caught at Kibwezi by boys, who put them in boxes and sent them by rail, at first to Makindu, latterly to Nairobi. On arrival, each fly was caught separately in a specimen glass and examined to decide to which species it belonged. Almost always only *Glossina fusca* and *Glossina pallidipes* were found; very rarely *Glossina longipennis* was caught. Each species was put in a separate box and fed at once on a monkey (called hereafter the "fresh-fly monkey"). A separate fresh-fly monkey was used for each species of fly.

I had originally intended to carry out the experiments as they had been done at the laboratory at Entebbe, with the addition of controls; but at Lieut.-Colonel Will's suggestion, the flies, after their first feed on the fresh-fly monkey, were starved for four days. It was found that if the period of starvation were prolonged beyond four days, very few flies survived. At the end of four days the flies were divided into two lots, one of which was used for the experiment, the other for a control. The flies for the experiment were now fed on the infected monkey, and after the proper interval, fed again on the clean monkey. The control consisted in taking the other box of flies and feeding them twice on the control monkey at the same intervals. These flies, therefore, were fed at the same time and as often as the flies in the actual experiment, and so, as long as the control monkey remained uninfected, gave some guarantee that the inital starvation had been sufficient to prevent them from conveying any Trypanosoma with which they might have been infected before capture. The experimental and control monkeys were of course the same throughout the experiment, though at first several experiments were abortive through the death of one or other of the monkeys. The infected monkey had to be replaced several times in the *Glossina fusca* experiment, but in the case of *Glossina pallidipes*, one monkey lasted till the experiment came to an end through lack of flies.

The infected monkeys came from Entebbe at the beginning of May. They had all been injected with cerebro-spinal fluid from cases of sleeping sickness, such fluid showing many active Trypanosomata. Of the four monkeys sent, one proved to be uninfected, but was infected at Makindu from one of the other monkeys. The strain was kept up by injecting fresh monkeys with a drop or two of blood from the finger of one or other of these three monkeys.

EXPERIMENT No. 1.

To see whether the *Glossina fusca* can convey the *Trypanosoma gambiense* from an infected to a clean monkey when fed on the clean monkey eight hours after feeding in the infected monkey.

In this experiment Monkey No. 9 was used throughout as fresh-fly monkey. Between July 1 and November 20, 348 flies were fed on this monkey, but it never became infected and is still healthy. Five infected monkeys were used, Nos. 2, 12, 4, 28, and 27.

Between July 18 and November 28, Monkey No. 13 had 368 flies fed on it, eight hours after feeding on the infected monkey. It never showed Trypanosomata in its blood until its death on November 28, nor were any signs of trypanosomiasis found on *post-mortem*. It apparently died of piroplasmosis, as did many other monkeys coming from the same place.

Monkey No. 11 was used as control, and had 761 flies fed on it between July 5 and December 5. It has never shown Trypanosomata in its blood nor any sign of trypanosomiasis. This experiment was ended by death of clean monkey.

EXPERIMENT No. 2.

To see whether the *Glossina pallidipes* can convey the *Trypanosoma gambiense* from an infected to a clean monkey when fed on the clean monkey 24 hours after feeding on the infected monkey.

Fresh-fly Monkey No. 22 had 85 flies fed on it between September 11 and November 10. Trypanosomata were found in the blood on November 20, seven days after feeding had been begun. The monkey died on November 29, and shewed no macroscopic lesion on a *post-mortem* examination.

Infected Monkey No. 24 had 296 flies fed on it between September 15 and December 10.

Between September 15 and December 5, clean Monkey No. 29 had 205 flies fed on it 24 hours after feeding on the infected monkey. It has never shewn Trypanosomata in its blood nor any sign of trypanosomiasis, and is still healthy.

Control Monkey No. 28 had 257 flies fed on it between September 14 and November 17. It has never shewn Trypanosomata in its blood nor any sign of trypanosomiasis, and is still healthy.

This experiment was ended by the infection and death of the fresh-fly monkey; no other being available to replace it. Throughout the experiments a routine weekly examination of the blood was made.

There is not sufficient material in these experiments to come to any definite conclusions. The results in the *Glossina fusca* experiment were entirely negative, and I am inclined to think that probably this fly does not convey any species of Trypanosoma. Whereas in the second experiment 85 flies fed over 60 days resulted in Trypanosomata being found in the blood on the seventieth day, in this case 348 flies feeding over five months and three weeks did not result in infection, although these flies came from the same noted fly belt as the *Glossina pallidipes.*

From the second experiment it is evident that the *Glossina pallidipes* can convey a Trypanosoma when fed on a monkey at least 16 to 18 hours after it could possibly have fed last. It is true that it did not succeed in conveying the *Trypanosoma gambiense* under the conditions of the experiment, but that by no means proves that it could not do so in Nature.

Round the shores of Lake Victoria, the *Glossina palpalis* is abundant and it is presumably this fly that there conveys the Trypanosomata of cattle, donkeys, &c. (*e g.* the "Jinja" Trypanosoma of the Royal Society's Reports). But this fly also conveys the *Trypanosoma gambiense.* At Kibwezi there is the *Glossina pallidipes* which has shown itself capable of conveying a Trypanosoma, and from the analogy of the *Glossina palpalis* in Uganda, it seems probable that the Kibwezi fly (*Glossina pallidipes*) will also be shown to be able to convey the *Trypanosoma gambiense.*

The results of the fresh-fly experiments make me inclined to think that there must be something more than direct transference with a soiled proboscis and that the mere number of flies feeding cannot be of the first importance. But there are also objections to the theory of a developmental phase in the fly corresponding to that of malaria in the mosquito. For I have had flies which, surviving in their boxes for weeks, were fed regularly during that time on blood rich in Trypanosomata, and yet they have never conveyed the parasite. It is as difficult to see why, given a developmental phase, these flies did not convey the disease, as it is to see why they failed, if it be only a case of direct transference. There is another possibility and that is that there may be an hereditary transmission from parent fly to offspring. I have never been able to get larvæ from either *Glossina fusca* or *Glossina pallidipes*, so have not been able to work at the question ; but in the light of Schaudinn's work it would seem to be worth trying, and if I can get the larvæ I hope to be able to carry out some experiments.

Having in view Schaudinn's work, I gave up using a low power when searching microscopically for Trypanosomata and used the oil-immersion entirely. But I have never seen any sign of an intracorpuscular stage of the Trypanosoma. On several occasions I have examined the blood of infected monkeys at intervals during the night, but have found the same results as when examined by day. There does not appear to be any increase in number nor could I find intracorpuscular forms.

I had at one time some monkeys whose blood showed a marked infection with *Plasmodium Kochi.* In a fresh specimen, flagellation occurred almost before one could get the lens focussed. I also examined the blood of these monkeys at intervals during the night, in the hopes of finding a Trypanosoma form. But the results were as negative as were those of the *Trypanosoma gambiense* in the opposite direction.

Through the kindness of Mr. Orloff (Assistant Surgeon at Makindu) Colonel Bailey and Mr. Percival (Game Ranger), I have been able to examine blood-slides from a fair number of animals. Most of the slides have of course been quite negative, but there are some results which are worth recording.

(1.) Blood of Mpala, shot and slide taken by Mr. Orloff. In this slide I found intracorpuscular bodies resembling in shape a mature Proteosoma, but showing no pigment. They stained blue with Leishman's, and showed small chromatin dots scattered throughout. The bodies were fairly numerous and a few were found free, presumably from damage to the blood-cells in spreading the film. Besides these bodies, there were a very few Spirillum-like bodies. These were about 18 long, sharply pointed at both ends, but considerably thicker (1μ) than the human Spirilla. Whether there was any connection between the two parasites in this animal I am unable to say, but the results in the two cases following seem to render it unlikely.

(2.) Blood of Coke's Hartebeest; shot and slide taken by Mr. Percival. In this I found the Spirillum-like bodies as described above, considerably more numerous than in the former case, but still scanty. Prolonged search failed to show any intracorpuscular bodies.

(3.) Blood of Thomson's Gazelle, shot and slide taken by Colonel Bailey. Here again I found the Spirillum as above, but could detect no intracorpuscular bodies.

(4.) Blood of Zebra. Slides taken by Mr. Stordy, Chief Veterinary Officer. The zebras were dying on Colonel Bailey's zebra farm at Athi river, from *Strongylus armatus.* In one of the slides brought to me by Mr. Stordy I found Piroplasmata similar in appearance to the parasite of African Coast Fever. This may prove of importance if it can be shown that the game is the source of infection of the various Piroplasmoses of which this country is full. But the difficulties in the way of experiments in this direction are very great.

The Flies. Both *Glossina fusca* and *Glossina pallidipes* were caught near Kibwezi Station. The country there is hilly, much of it covered with dense bush. The Kibwezi river rises in springs near the station and runs down the bottom of the valley. The *Glossina pallidipes* was caught on the edge of the bush or in open spaces where animals, chiefly goats, were grazing, but never at any great distance from the water. There seems to be a marked seasonal prevalence in this fly ; until towards the end of August hardly a specimen of it was caught, but from August to November more flies of this variety than of *Glossina fusca* were caught. This period is the driest season of the year. This fly (*Glossina pallidipes*) has a very wide distribution in this country and seems to extend along a great part of the Athi and Kiboko rivers. Major Pope Hennessy has sent me specimens from the Gosha forest in Jubaland.

In contrast to the habits of the *Glossina pallidipes* are those of the *Glossina fusca.* This fly can be most easily found on the slightly damp black cotton soil between the boulders on the hill-side. The *Glossina pallidipes* attacks as soon as one gets among them, but the *Glossina fusca* shows no inclination to bite men. Christy (Reports of Expedition to the Congo, 1903-1904) suggests that the *Glossina fusca* bites at night, but I have no information on the subject. It can only be said that this fly shows little inclination to bite by day, is usually found on damp soil, and its numbers do not seem to be affected by the presence or absence of stock. It has been caught throughout the year but is most numerous in the wet season.

The *Glossina longipennis* has not been found at Kibwezi, but at a station further down the line (Kinani) has been caught in quantities. Along the railway line and the old caravan road, where there is little or no bush, the fly apparently rests on the red soil, flying up and attacking any animal or man passing by. It is as troublesome as the *Glossina pallidipes* in this way, but apparently does not bite all day ; for one can go along the line at midday without seeing a fly, but after 4 p.m. one is immediately attacked. This fly enters the train regularly at night and can be found flying about the lamp. My Indian Assistant, Compounder Pillay, through whom I have obtained most of my information about the flies, tells me that he has never found a *Glossina longipennis* come on board the train in the daytime, but at night they are attracted by any light and will then bite. This fly is found between the Tsavo and the Mtoto Ndi rivers. A few specimens have been caught outside these limits, but they have been in the railway stations and have evidently been carried by the train. I have not been able to find out anything about the seasonal prevalence of this fly.

18. REPORT ON SLEEPING SICKNESS IN UNYORO AND THE NILE VALLEY.

By A. D. P. Hodges, M.D. Lond., Medical Officer, Uganda Protectorate.

1.—*Summary of Report.*

The route traversed after leaving Hoima was :—Masindi, Fajao, Foweire, Fajao, Wadelai, Lake Albert (by water), Wadelai (by water), Nimule (by water), Gondokoro.

On my arrival at Hoima I saw cases of undoubted sleeping sickness which had been brought in from Bugungu (Bachopi) by Dr. Pooley, and had been subsequently seen by Capt. Greig, I.M.S., of the Sleeping Sickness Commission. These cases were in all stages of the disease, which had been contracted locally.

The presence of sleeping sickness in epidemic form in N.W. Unyoro was therefore certain, and, as I found that Dr. Pooley had just recently passed through the Butiaba, Fajao lines of country, and Capt. Greig was then again traversing a part of it, I was induced, with the permission of the Principal Medical Officer, to alter my intended route along that line to one further inland, including Masindi, Fajao and Foweire, in order to ascertain, if possible, the extent of the epidemic, the prevailing local conditions likely to influence its spread, and its origin; especially, whether it had travelled directly by the supposed fly-belt along the Nile from the Victoria Nyanza epidemic. I was further persuaded to take this line by hearing that there were, or had been, a good many sick people at places near the Masindi-Fajao road.

The centre of the present epidemic appears to be in that part of the Bachopi country lying in the angle formed by the Victoria Nile and the eastern shore of Lake Albert. In this area there have been a considerable number of deaths, which, from facts gathered by Dr. Pooley and from widely varying native reports, I should judge already amount to several hundreds. An estimate is rendered more difficult, if persistent native reports are to be believed, by the co-existence, during the last year or so, of small local epidemics in the same area of an acute and rapidly fatal disease, called by the Bachopi "kituli," which appears to be the same as the Luganda "kaumpuli," and is probably plague.

There are no reliable data available to show how long the sleeping sickness epidemic has been going on, but, calculating from the alleged number of deaths and the proportion of sick who have been seen in a late stage of the disease, it would appear that it has lasted at least a year, probably more. No evidence is obtainable as to how the infection first reached this epidemic area, but the probabilities of the case will be referred to later on.

Sleeping sickness was not found to be present as an epidemic anywhere along the route followed, which included the places mentioned above and extended to a point about ten miles west of Fajao in the direction of Bugungu. A few isolated cases were seen at widely distant points.

I was, unfortunately, prevented by want of transport, my porters being worn out, from traversing the country in the angle formed by the Victoria and White Nile, where, from what I have learned of the nature of the country and its population, I thought the disease likely to spread, but I visited part of this district on the bank of the White Nile by steamer later.

Glossina palpalis was found to be widely distributed on the Nile and lesser streams, and facts were gathered as to its local distribution and habits. The conditions favourable to the spread of sleeping sickness exist over a much wider area than the epidemic itself, as will be shown. They seem nowhere, however, unless perhaps on the shores of Lake Albert, favourable to the occurrence of a great epidemic such as that on Victoria Nyanza.

With regard to preventive measures, no complete system of quarantine or isolation would be possible owing to the characteristics of the disease itself, and if attempted would paralyse traffic and transport over a great part of the Protectorate and elsewhere. The prospects of destroying the fly to any useful extent is apparently hopeless. The measure which will be recommended as most likely to be effective and most generally practicable is a form of local and partial segregation which can be carried out by the natives themselves, and which consists in removing sick and suspected persons from communication with the neighbouring area or areas infested by fly.

II.—*Enquiry into the Presence of Sleeping Sickness.*

Great difficulty was experienced everywhere north of Masind in gaining any assistance or reliable information from the natives, who have had little to do with Europeans and who were found to be extremely shy and suspicious and much prejudiced against showing their sick, their time-honoured custom being to hide them away in the jungle on the approach of strangers. They invariably denied all knowledge of the disease or of its presence in their country, except that, in a few instances among the Bachopi, they said they had heard of its presence at Mwanga's (Bugungu). They had, or professed to have, no name for it. It is perhaps worth noting here that I never found a sick person of any kind in a village in which it had become known that I was in search of sleeping sickness. There was great difficulty, also among the Bachopi in getting interpreters, as these people seem to have mixed very little with Baganda or Swahilis and generally knew only a few words of Sudanese, if any.

One could, therefore, form a judgment as to the presence of an epidemic only on general grounds, such as the general health and condition of the people, the state of the villages, gardens, etc., and the presence of recent graves. It can be stated with practical certainty, however, that, along the route followed by the expedition, excepting possibly the neighbourhood of the Waiga River, which will be again referred to when speaking of plague, sleeping sickness was not present in epidemic form, though isolated cases, if they existed, might easily have been concealed.

Having heard that there was, or had been, an epidemic of some kind near Kiswata's, on the Masindi-Fajao road, I obtained an interview with Rubaugu, the chief of that district, at Masindi, in which he promised to collect the sick for me at the Waiga River camp, which is near there, and to provide guides. When I arrived, however, I found that nothing had been done and I could obtain no guides who would tell me in what direction the sick people lay. I was told on my arrival that all the sick people, five in number, had died the day before. After waiting two days, however, a woman was brought to me in a moderately advanced stage of sleeping sickness. She had general superficial glandular swelling, and gland-puncture in the neck revealed the presence of Trypanosoma. I could find no other cases, however, and the people there denied all knowledge of sleeping sickness, though they circumstantially described a recent epidemic of what they, the Bachopi, call "kituli," which is probably plague, and which they said had now disappeared. The woman just mentioned was stated to have frequently visited Lake Albert, near the mouth of the Waiga, and to have also been to Mwanga's (Bugungu), but it was also said that she had only been ill five days.

Between this and Fajao the population near the road is very scanty and I could find no case in which there was any suspicion of sleeping sickness, while at Fajao itself, which appears to be only too well adapted to the spread of the disease, the natives denied all knowledge of it, and I could find no sign of its presence. Enlarged glands were not common, but three cases were tested by gland-puncture with negative result. From Fajao to Foweire the conditions are less favourable to the spread of the infection, and here again all knowledge of the disease was denied. Enlarged glands were comparatively uncommon, and though several cases were tested by gland-puncture in various villages, in all eleven, the results were in each case negative.

Between Fajao and Wadelai I saw no natives, as they all ran away and did not even sell food to the porters. Between Lake Albert and Wadelai, near the former, on the Bank of the White Nile, at a village called Kobo's or Buba's, I saw one man with well-advanced sleeping sickness, having muscular tremor and enlarged glands. Not only, however, would he not allow me to examine his glands by puncture, but he refused even to put out his tongue. I saw one child in the same village whose condition was very suspicious, but any attempt to examine it gave much alarm, and I saw no more cases.

The natives north of the Victoria Nile appear to be afraid of witchcraft, and regard all European medicine as magic. At a village in the Bari country they said: "you would not go to see a man performing the calls of Nature, why should you want to look at him when he is sick?" so that in some cases they appear to be ashamed of being ill.

At Wadelai, Dr. Strathairn told me that Capt. Greig had found trypanosomes by gland-puncture in one of the police, and he showed me a Uganda woman who seemed to be in an early stage of sleeping sickness, though a single gland-puncture in the latter case gave negative results. It is probable that the infection was not contracted locally in either of these cases, but they are of interest in considering the origin of the infection of Lake Albert and the Nile Valley.

At Kerris, half-way between Gondokoro and Nimule, I heard that there was a sick woman in a village, but on visiting it had great difficulty in seeing her, and was at last permitted to do so only on promising to abstain from medical or surgical interference. I was therefore unable to test by gland-puncture, but she was evidently in the last stage of sleeping sickness, and had been many months ill. She had been brought there from Nimule, where she was taken ill, and where, it was stated, other cases exist among the natives. She was alleged to have always lived at Nimule or Afuddu, and in that neighbourhood, and never to have visited Uganda or Unyoro.

I found no sign of the presence of sleeping sickness north of this.

III.—*The Fly.*

Glossina palpalis was not observed until the Waiga River was reached, where it was seen in small numbers at the point where the road crosses the river. It was afterwards found on so many of the streams encountered (unless where the channels were completely dry) that it is probably present on most or all of them wherever and whenever the conditions are favourable to it. It was, however, very scarce on the smaller streams, and often difficult to find. On the Victoria Nile it was numerous on both banks at all the points visited, and is probably practically continuous along the river as far as the rapids extend. On the White Nile it was numerous on both banks wherever the conditions seemed to favour its presence, but its distribution was more patchy. It was not found on either bank at Wadelai itself, nor between that place and Nimule, but at the latter locality it is again plentiful. It was also found at various points further down on the Nile. The furthest point north at which it was met with was near a small stream about 35 miles south of Gondokoro, between Kanda and Shindiro. It was seen on most of the streams further south.

It is probable that *Glossina palpalis* is present on all streams and open water where certain conditions prevail, viz., open water with shade, and a certain amount of clear beach, bank, or rock. Thus, on the Victoria Nile, which presents much the same features between Fajao and Foweire as the same river in Busoga—namely, high cliff-like banks covered with rock and scrub overhanging running water—the fly is extremely abundant. On the Nile from Lake Albert to Wadelai the conditions are more varied, but wherever the bank was fairly clear of close high reeds, swamp, or sudd, and was moderately shaded by jungle or even small scrub, the fly was always found. Where the bank was free of reeds, sudd, jungle, or scrub the fly was rare or absent. Behind a wide expanse of close high reeds, swamp, or sudd, even if there was shade along the coast itself, the fly was also rare or absent ; but it does not seem to mind open reeds, weeds, or rushes, or a narrow belt of swamp. As the above sets of condition may be said, roughly, to alternate with the curves of the river on the banks of the Nile at this part, the fly may be imagined as distributed in a line which zigzags irregularly across the river. At Wadelai, however, and from there to Nimule, with much sudd and swamp on both sides, only a little clear bank, and rarely shade at the same time, the fly was not found. At Nimule again, where there is shade without swamp, and north of it more or less clear banks owing to the rapids, the fly was found at several points. It is probably present wherever there is a belt of shade. In the immediate vicinity of Gondokoro, where there is no shade there is no fly. On the lesser streams and rivers the fly was generally in small numbers only. The conditions determining its presence there are similar to those of the main river. Where the stream is very narrow, high grass appears to give sufficient shade, and high perpendicular banks are also always favourable The fly was found to be fairly abundant at some waterholes left in the dry beds of streams, being probably concentrated at places where water remained. It was not met with along channels which were entirely dry, nor was it seen at swamps or waterholes apart from streams.

There is in reality no continuous fly-belt, and, though it has been customary to use the term as referring to the range of the fly from a given piece of water, it will probably be found more convenient to reserve it to determine the geographical distribution of the fly across the continent of Africa. What is found locally is rather a series of patches on lake or riverside which may or may not be continuous.

The range of the fly from the water side is probably much narrower than has been supposed. Only on a very few occasions was it seen in ones or twos at any distance from water. The outside limit may be given as 300 yards, but seldom exceeds 50 or 100 yards. Probably on all the occasions on which the fly was found at a distance from water it was following the caravan ; in fact, as was early noted, it will follow people from water to a certain distance till it has fed or been driven off. It was never met with while approaching water at any distance from it. Although I often camped at 100 or 200 yards from water where the fly existed, I only on one occasion found a fly in camp, and this had evidently followed the water carriers. In the camp at Fajao, where I spent altogether on two occasions nearly three days, I never saw a fly, though the tents were pitched close to the river on a high cliff beneath which the fly was to be seen in great numbers, and I had offered a reward to the porters for each fly caught away from the water side. It is possible that the range of the fly may be increased in thick forest or in wet, cloudy weather, but this I had no opportunity of testing.

It was noted that *Glossina palpalis* will come freely to a boat off shore at a distance of about 30 yards or less but rarely at a greater distance. It will remain on board for a long time and may be carried for at least several miles. It does not begin to bite, as a rule, till the sun is well up, and it is difficult to be found half an hour before sundown. The surest way to detect its presence is to sit down close to the water's edge and wait, either in the shade or in a small open space. It may sometimes be necessary to remain half an hour or an hour or even more before seeing one, and it is well to have one or two natives sitting or standing in front of the observer. After a little experience the fly's presence may usually be detected by the ear before it is seen. It prefers to settle near the ground, especially on the under parts of the body such as the bends of the knees and backs of the calves when one is in the sitting posture.

The Bangoro call biting flies "bwara" if large, and "kiwara" or "kivara" if small, but appear to have no special name for the tsetse flies. The Bachopi call the tsetses "malingwa." They say that *Glossina palpalis* "follows the hippopotami," but it was found in many places where these animals seldom or never come, and was absent from others where they abound. The natives north of the Victoria Nile use the term "buda," which is applied by the Sudanese to any insect which bites by piercing, including mosquitoes. The tsetse is sometimes called "buda kebir." Several chiefs near whose villages the fly was found said they had never seen it before, though it seems that some of them, at any rate, had been shown it by the Collector of this district. The specimens of biting flies collected by me have already been sent in.

IV.—*General considerations.*

The following facts and conclusions seem to me to be of chief importance for consideration in dealing with sleeping sickness:—

1. The infection (trypanosome) can be carried from person to person only by the infected fly, and from place to place only by infected persons, viâ the infected fly.

2. If, as is stated, *Glossina palpalis* can carry the infection only for 48 hours or so, the risk of its conveying it to human beings in a given area must vary extremely according to the number of people in it or visiting it, the number of flies and the frequency of their opportunities for biting the sick. The scarcity of trypanosomes in the peripheral blood of the sick diminishes the probability of the fly acquiring or conveying the infection by any one bite, and so emphasises the importance of decreasing its opportunities as much as possible. The fly soon ceases to be a danger unless constantly re-infected.

3. The human being, on the other hand, may carry the infection for many months and possibly for years, and is a

constant source of danger so long as he is in or communicating with the fly-range. If kept from contact with the fly, however, he is harmless.

4. The range of the fly from water is very narrow, probably less than a quarter of a mile, and usually much less.

5. The risk of infection is at its maximum in a community or village situated within the fly-range, for there the sick people constantly re-infect the flies, and a village partly within the fly-range is practically in the same case. Between villages situated within a fly-range or ranges there is reciprocal infectiveness. This is particularly noticeable along lake shores and navigable rivers and among islands.

A village, the greater part of whose population is employed daily within the fly-range, as in fishing or canoeing, is almost in the same case with one lying within the fly-range, with the important exception that, in the later stages of the disease, when the sick are peculiarly at the mercy of biting insects, they no longer visit the water-side.

6. Such villages as those mentioned above are of especial danger on a line of frequent communication.

7. In a village whose inhabitants visit the fly-range only for drawing water or for ablution the risks are greatly diminished.

8. In a village away from the fly-range a great part of the population may become independently infected, and the risk varies with the distance from the fly-range and the frequency of communication with it. It is greatly increased in certain situations, such as on peninsulas or islands and between rivers (*See* Figs. I, II, and III). In such villages the able-bodied are the most liable to infection and are usually the first attacked. Infection cannot be carried directly from such a village to another outside the fly-range, but can only travel viâ the fly-range.

9. Infection is carried from place to place by man and not by the fly, though an infected fly might conceivably be carried for a considerable distance artificially, *e.g.*, on a steamer. It is evident that persons in the early stage of trypanosomiasis may carry infection to great distances, while the range of the individual fly is narrow and the period during which it carries infection is short. It is probable, therefore, that fresh areas become infected viâ the main routes of communication, rather than from more or less adjacent fly-infested belts or patches through which there is little or less communication.

10. The risk of infection being carried from one place to another depends then, chiefly, on the amount and character of the communication between them. The greatest risk is run when this is entirely or principally within the fly-range, as it commonly is along lake shores and navigable rivers. The most marked example is to be seen in the canoe traffic of the natives, in which the course is, wherever possible, in-shore, and the landing-places are frequent and generally uncleared. The danger is

comparatively slight of the infection travelling along or across unnavigable rivers, such as those parts of the Nile where there are rapids, and is determined more by the extent of road-communication than by the river itself and the number of flies on its banks. The risk from an infected person travelling depends on the number and character of the fly-infested areas crossed and, especially, on the time spent in them. It is obviously greatest when an infected person settles, or remains for some length of time, in or in close communication with an infectable area.

11. The conditions necessary for the occurrence of a great epidemic may be stated as follows:—

(1.) The presence of *Glossina palpalis* in large numbers over a considerable area.
(2.) A thickly-gathered numerous population.
(3.) Free and frequent inter-communication, much of it within the fly-range.
(4.) A considerable part of the population either living or daily employed within the fly-range.
(5.) A coast or banks much broken by inlets, estuaries, and rivers, and with adjacent islands.

These conditions may be summed up as the constant infection and re-infection of large numbers of flies and the exposure to them of large numbers of people. They will be comparatively rarely found to co-exist in such fatal completeness as they do round the northern shores of Victoria Nyanza.

V.—*Preventive and Precautionary Measures.*

Sleeping sickness, then, may be carried wherever an infected person travels—a possibility which is practically unlimited. The disease may spread and find new victims wherever *Glossina palpalis* exists—a very wide field indeed. The chances of its spreading locally will, however, vary with certain conditions, such as the number of flies, the number and habits of the population, the location of their dwellings, the amount and kind of intercommunication and the conformation of the country. Most of the preventive measures used to combat other epidemic diseases are inapplicable in dealing with this terrible and fatal malady, and the difficulties to be overcome in carrying out any measure efficiently are enormously increased, not only by the special characters of the disease itself but also by the nature of the countries and populations where it is prevalent.

Quarantine, properly speaking, is impossible, owing to the great length of time during which infection may be carried by human beings and the difficulty of determining its presence in the early stages.

Aggregation of the sick for isolation purposes in large numbers is attended with great difficulties and drawbacks, and has no special advantages. Such aggregation within the fly-range must of course be harmful.

The difficulties in the way of quarantine preclude the feasibility of preventing the infection from being occasionally conveyed, wherever there is communication, to a new infectable area, and, though this may be controlled to some extent, it would seem that greater success is to be hoped for in endeavouring to limit the infection of flies in new areas and their re-infection in epidemic areas so as to reduce the risks to or from residents or travellers in each locality as far as possible.

The most practical method of accomplishing this result would be the removal of the sick in each community from direct communication with the neighbouring fly-range. This range being generally very narrow, the purpose would be effected in most cases by moving the infected patients to the next hill or open space, which need not be more than half an hour from the water-side. They would have to be supplied with water and sometimes, but not necessarily or always, with food as well, by their neighbours. This plan would of course be more difficult in a district in which a large proportion of the population had already contracted the disease. The chief difficulty will always be with cases of early infection. If, however, this plan were only partially carried out it would enormously decrease the risks incurred by the constant re-infection of flies. Where it could be carried out thoroughly it would stamp out the disease, and it should be enforced primarily at camps and villages on the main lines of communication.

It is probable that the natives, though generally reluctant and suspicious of anything new, would not have the same prejudices against such a measure as they have against complete isolation and removal to a distance from their homes and friends. Chiefs and others in districts where the infection exists or is likely to penetrate should be shown specimens of the fly and instructed as to its habits and how it carries infection, and special stress should be laid on the fact that only when it is allowed to bite the sick does it convey the disease to others. They should also be given some idea of the course and duration of sleeping sickness, and warned as to the early attacks of fever. They could then be instructed to remove all sick and suspected persons to a distance half an hour from any water where the fly is, to prevent them from visiting such water and to see that their friends supply them with water and food. They should report the appearance of cases of sleeping sickness in their district as they occur. Where feasible whole camps or villages could be removed from within the fly-range. In villages outside the fly-range it would only be necessary to prevent the sick from direct communication with it.

Instructions similar to the above were given to the chiefs at villages through which I passed. These men seemed quite willing in most cases to carry them out for their own sakes, if occasion arose, and did not suggest any difficulties in the way. With the support of the administrative authorities I think that

FIG II.

DIAGRAM OF THE PROBABLE MODE OF EXTENSION OF SLEEPING-SICKNESS IN BUGANDA & BUSOGA EPIDEMIC A.

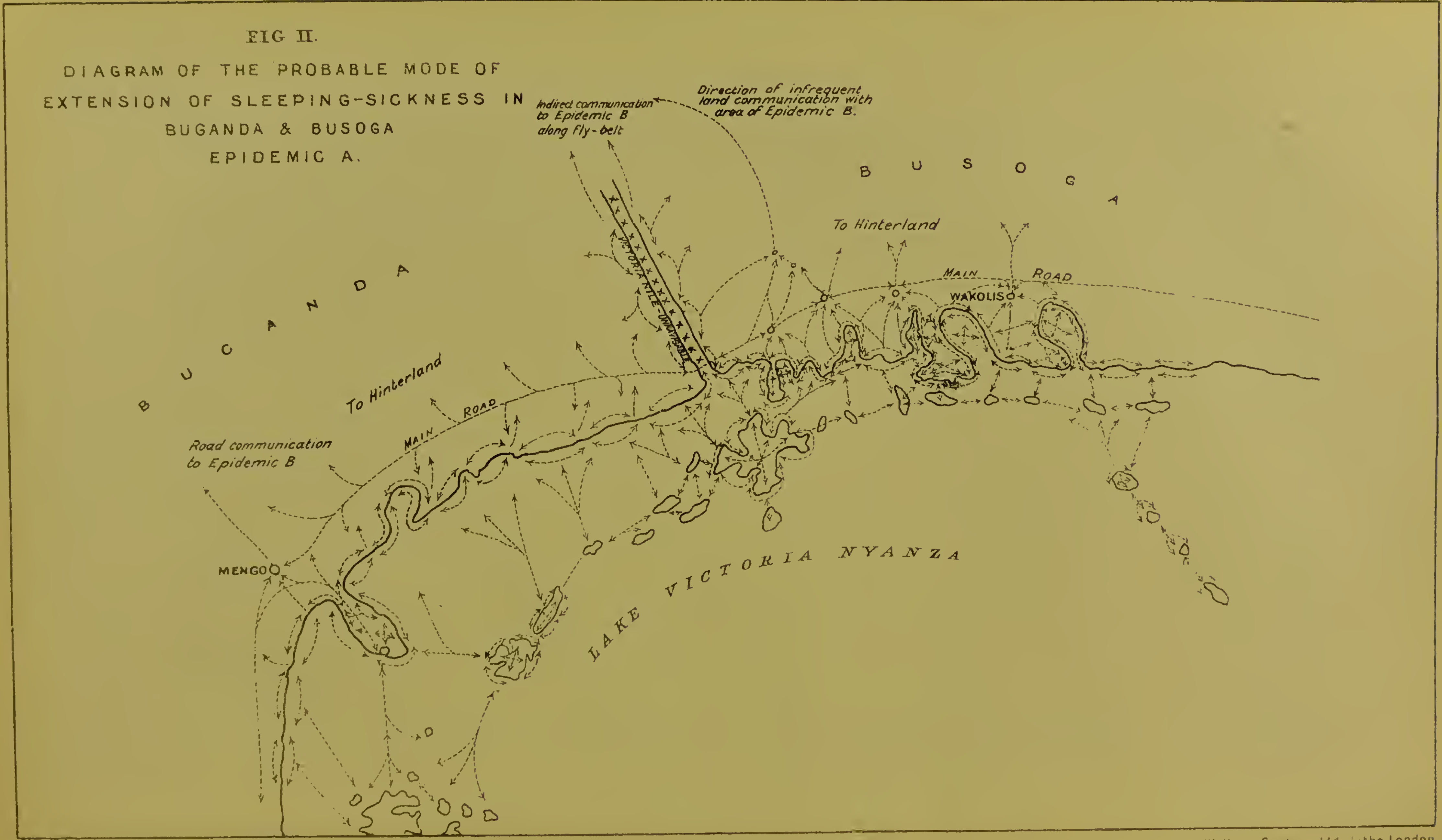
Indirect communication to Epidemic B along Fly-belt
Direction of infrequent land communication with area of Epidemic B.
B U S O G A
To Hinterland
MAIN ROAD
WAKOLISO
VICTORIA NILE—UNNAVIGABLE
B U G A N D A
To Hinterland
MAIN ROAD
Road communication to Epidemic B
MENGO
LAKE VICTORIA NYANZA

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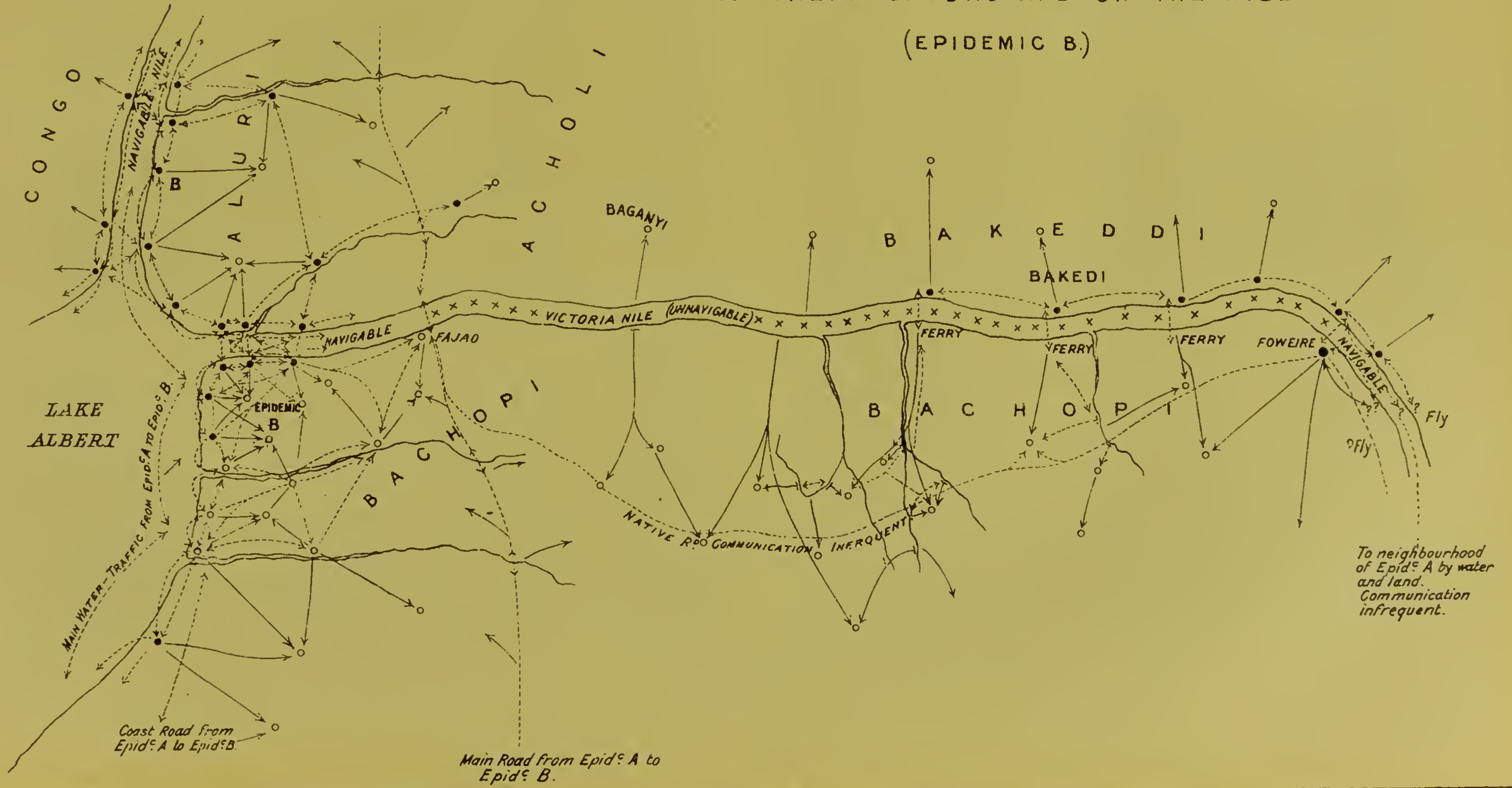
FIG. III.

DIAGRAM SHOWING CONDITIONS OF POSSIBLE SPREAD OF SLEEPING-SICKNESS IN NORTHERN UNYORO AND ON THE NILE.

(EPIDEMIC B.)


CONGO
NAVIGABLE NILE
B
ALURI
ACHOLI
BAGANYI
BAKEDDI
BAKEDI
VICTORIA NILE
(UNNAVIGABLE)
NAVIGABLE
FAJAO
FERRY
FERRY
FERRY
FOWEIRE
NAVIGABLE
Fly
?Fly
LAKE ALBERT
EPIDEMIC B
BACHOPI
BACHOPI
NATIVE RD. COMMUNICATION INFREQUENT
MAIN WATER-TRAFFIC FROM EPIDc A TO EPIDc B.
Coast Road from Epidc A to Epidc B.
Main Road from Epidc A to Epidc B.
To neighbourhood of Epidc A by water and land. Communication infrequent.

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Weller & Graham, Ltd Litho. London.

many of them would do their best to follow any such instructions given them. Where chiefs are found unwilling or incapable it might perhaps be possible to find Baganda, familiar with the disease, who could be employed, in some parts of the country, as native inspectors, and would see the instructions carried out.

Precautionary measures such as the medical examination of those travelling from an infected to an infectable area should of course not be neglected. Persons having glandular enlargement might be tested by puncture. People from an infected area should not be allowed to settle for any length of time in an infectable area without medical examination and special permission, and, when such permission is granted, should report themselves periodically.

Camps for transport purposes should not be nearer than 200 yards, and where possible 400 yards, from the water, and the ground near crossings and places where water is drawn should be kept well cleared of scrub. Where it is absolutely necessary to have camps near the water-side the sites should be carefully chosen and prepared. Water traffic should be conducted where possible at least 50 yards from shores or banks likely to harbour the fly, and landing-places should be chosen at spots which it is not likely to haunt.

The actual manner in which sleeping sickness spreads is highly complex, owing to the peculiar distribution of the fly and the various ways in which it can be reacted on by human intercommunications and occupations, and by the conformation of the country.

The map diagrams accompanying this report are intended to demonstrate how infection probably spread in the Victoria Nyanza epidemic (Epidemic A, Fig. II) and how it may possibly extend in and from the Albert Nyanza epidemic (Epidemic B, Fig. III).

The coast lines are entirely diagrammatic. Lines with double arrow heads (←→) show how infection is carried in both directions between any two points within the fly-range or from one fly-range to another, and represent, what has been called above, reciprocal infectiveness. Lines with single arrow heads show infection travelling to points without the fly-range, and represent so-called imported cases.

In Fig. I, E = lake or navigable river; F = fly-range; A, B, C, D = villages within fly-range; a, a^1, a^2 and b, b^1, b^2 = villages outside fly-range. All cases or centres in A, B, C, D are reciprocally infective, while a, a^1, a^2 and b, b^1, b^2 can only infect one another through some infected point in F, and are not reciprocally infective with A, B, C, D. (Fig. I, *see* p. 99.)

In Fig. II an attempt has been made to show the influence of islands, peninsulas, &c., on intercommunication and reciprocal infectiveness, and also how certain communities, though outside the fly-range, may be so situated that the greater part of their population may be swept off in a great epidemic while they themselves cannot convey infection directly to other communities outside the fly-range. An instance of this is the place marked Wakolis.

In Fig. III, I have tried to show how sleeping sickness may be expected to spread in the Lake Albert epidemic, and I am persuaded that a fairly accurate forecast might be made were a more detailed knowledge of the country and its inhabitants available. For greater distinctions only the lines showing reciprocal infectiveness have been marked in red.

It will be seen that the conditions favourable to the occurrence of a major epidemic are present to a great extent on the N.E. shores of Lake Albert and on arms of the Nile near it. It is possible they may also exist at other parts of the lake shore. There are, however, several reasons which render unlikely an epidemic of anything like the dimensions of that about Lake Victoria, namely :—

1. There is nowhere such a large and thickly gathered population.
2. There is much less intercommunication and trade.
3. There is nowhere so large a proportion of the population following their daily avocations within the fly-range.
4. On the White Nile, at any rate, most of the dwellings seem to be situated outside the fly-range.
5. What I have been able to gather regarding the conformation of the coasts and banks and the number of islands leads me to believe that the country is less fitted for the spread of infection. Between Foweire and Fajao nearly all the villages are some miles from the Nile, many of them draw water from springs and waterholes not directly connected with streams, and most of the others are at least half a mile from streams. The fly is scarce on these streams, communication is infrequent, and the inhabitants have practically no aquatic occupations. Of the Bakedi and others occupying the country to the north of the Victoria Nile I can say little, except that they appear to control both banks of the river and to engage to some extent in fishing.

Along the White Nile to Wadelai the population is comparatively thin. Between Wadelai and Nimule the fly is scarce or absent (it may, however, be present on the streams) and the population is also thin. North of Nimule the population is again scanty and the river is, of course, unnavigable, but the road touches it at many places. There is no native intercommunication in all this region comparable with that among the Baganda and Busoga.

It would seem, therefore, if the infection makes headway in either of these directions, that a series of village or minor epidemics is more likely to result than a major epidemic like that round Lake Victoria.

Other diseases met with were small-pox and relapsing or spirillum fever. A disease resembling plague was described by the natives as existing in Unyoro and in the Bari country north of Nimule. Only one case of small-pox was seen, a porter in a caravan coming from Uganda. This man was isolated by arrangement with the local chief of Fajao and afterwards passed on to Gondokoro. No further cases, so far as can be ascertained, resulted.

Spirillum fever was common in my caravan, and several cases were met with in native caravans encountered on the road. In all 21 cases were seen and verified by microscopic examination. This disease seems to be specially prevalent in Unyoro. No cases occurred north of the Victoria Nile which might not have been contracted south of it, and no case has been seen since arriving at Wadelai. The disease seems to be closely associated with the tick *Ornithodorus moubata*, and is therefore probably identical with the Zambesi "tick fever." Some interesting cases occurred among my own servants. On December 14th my servants complained to me that there were many of the ticks, called "Bibo" by the Baganda, in the rest huts at the camp where they had slept that night and the night before. They had previously slept in their tents and I ordered them to do so again in future. On the night of December 21 four of them were seized with sharp attacks of spirillum fever. As, so far as I and they could tell, there had been no further exposure to the tick (which is *Ornithodorus moubata*), these cases appear to throw some light on the causation and incubation period of spirillum fever. Only one of these four had a relapse, after an interval of 14 days. Relapses were not common in the other cases, and seems to be much less frequent in natives than in Europeans.

At Kiswata's, near the Waiga river, Mwechi, a "mukungu" there, told me that 6 months before my arrival 41 people had died in a shamba called Panyatoli of a disease which lasted from two to five and sometimes ten days. They had pain in the chest, stomach or neck and sometimes in the groins. Sometimes, also, they spat blood or passed it in the stools. This disease is called locally "kituli" and is apparently the same as "kaumpuli" in Luganda and probably identical with plague. Mwechi said he remembered it, in Kabarega's time, before the Europeans came, sweeping across the whole of Unyoro and killing many people. All who did not die left their shambas and villages and ran away. He had not noticed whether rats died. He said the local epidemic was now finished, and I could not see a case, though five people were said to have died of some disease or other the day before my arrival.

At Kerri's, half way between Nimule and Gondokoro, I found a small village quite lately deserted and partially burnt, with at least one recent grave in it. A son or relative of Kerri who was with me at the time, told me that it had been deserted during the current month (February) on account of an illness of which two people had died, and which he described as lasting from two to five days with symptoms similar to those described above. The local name of this disease is "jeddr." At a neighbouring village, when I found a case of sleeping sickness, this story was denied, and my original informant seemed inclined to retract his story, but I rather think it was nevertheless true, as no other reason was vouchsafed for the desertion of the village. No case of malaria occurred among the natives in the caravan until Wadelai was reached.

APPENDIX TO DR. HODGES' REPORT ON SLEEPING SICKNESS IN NORTH-WESTERN UNYORO AND ON THE NILE.

Other Biting Flies.—In addition to *Glossina palpalis* several kinds of biting flies were noticed. Specimens of most of these have already been sent and they appear to consist mainly of Tabanidæ of various species and Simulium or sand-flies. The latter are found in quantity near the Nile, especially the Victoria Nile, but their distribution is very wide over Usoga, Uganda, Unyoro and the Nile Province. Tabanidæ are also widely distributed, but were seen in greatest numbers between the Victoria Nile and Wadelai. Biting midges (Ceratopogon?) were troublesome at Hairo camp, between Kampala and Hoima, and at various places along the Nile. They are about ⅛ inch long, greyish, with small hairy spots on the wings. Unfortunately all the dry specimens collected, which included mosquitoes, midges, and some of the tsetse flies, were spoiled either by mould or putrefaction.

A tsetse fly, somewhat smaller than *Glossina palpalis* and of a more yellowish-brown colour, was seen at intervals along the native road from Foweire to Fajao. It seemed to be pretty widely scattered, but was nowhere numerous, and I found it difficult to catch. One specimen, which appeared to me identical with those I had seen, was caught by one of my servants on his neck, about five hours south-east of Fajao. This has already been sent in for identification. I next saw similar flies about two hours north of Fajao, near the Wadelai road, but failed to obtain a specimen, though, while trying to catch one which was settling on my putties, I was bitten by another on the back of the neck, the first intimation of the latter's presence being the peculiar buzzing noise which they make after feeding, and which was long ago described by Colonel David Bruce. I did not encounter them again till about half-way from Nimule to Gondokoro, where I saw and caught a single specimen, which I now send. Since arriving at Gondokoro, however, I have found them in considerable numbers at a spot about four hours east of the station, near the Kodweh (?) river. Here I succeeded in catching three specimens, which also I send herewith. I cannot, in the absence of any literature of reference venture to determine the species, but, from their small size and general coloration these flies seem most to resemble *G. morsitans*.

Trypanosomes in animals.—On January 6th, at a camp near Foweiro, it was reported to me that one of some sheep I had brought with me from

Kampala seemed to be sick and could not keep up well with the caravan. As the weather was intensely hot and trying I was not surprised. I took the animal on the next day, when it was reported to be weaker, and it was carried for a short distance into camp, where, however, it immediately started feeding. I could detect nothing the matter with it but a very slight nasal discharge, but, as it could not keep up with us, I ordered it to be killed, previously taking a fresh specimen of its blood. In this I found two trypanosomes. I then took some dry films for staining, but by this time the state of the blood was unfavourable for microscopy and I found no trypanosomes in them. I also failed to find Pyrosoma or any other parasite. In the organs there were definite signs of disease, viz., pericardial effusion, and some petechial hæmorrhages beneath the pleura.

Soon after my arrival at Gondokoro I was informed that the Government mule used by the collector was ill. In its blood I found trypanosomes, and it died on March 2nd. At the *post-mortem* examination I detected nothing abnormal beyond anæmia and a few sub-pleural and sub-pericardial hæmorrhages. The brain was not examined. As the animal had been at the station three years the disease must have been contracted in this district.

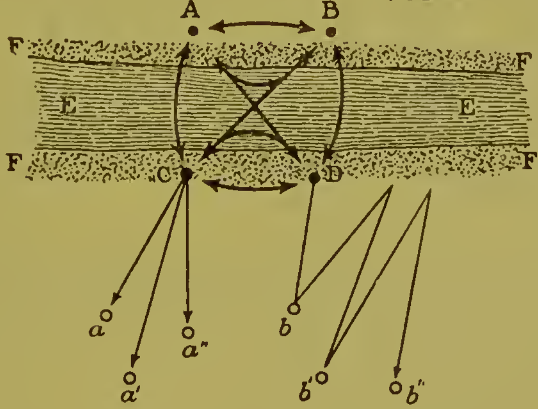
ADDITIONAL NOTE BY DR. HODGES, DATED SEPTEMBER 6TH, 1905, GONDOKORO.

The identification by an expert of the tsetse flies sent in with my report having confirmed my supposition that certain of these flies belonged to the species *Glossina morsitans* I am enabled to state now, what I suspected at the time, the fact that in every instance in which tsetse flies were caught at any considerable distance from water and from localities such as are described in the report as being affected by *G. palpalis*, the species has proved to be *G. morsitans.*

This would seem to be a somewhat important point in mapping out the distribution of *G. palpalis*, as it will be evidently rash to conclude tha tsetse flies reported as existing away from localities such as described are of the species *palpalis*, unless specimens have been caught and examined with a view to the exclusion of other species.

Another fact brought into prominence is the very wide belt of distribution of *G. morsitans* across Africa, and this would seem to emphasise the importance of experiments as regards the ability of this species to carry the trypanosome of sleeping sickness, and thus to determine the potentiality of the spread of this disease to the many important areas where this fly is known to exist.

FIG. I.



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19. ACCOUNT OF TOUR BY MR. SPEKE AND DR. ADAMS IN NORTHERN UNYORO AND ON THE VICTORIA NILE.

By Dr. E. B. Adams.

(*November* 14, 1905.)

On September 8th, 1905, Mr. Speke and I started from Hoima on a tour through the Bugungu country to Fajao, thence along the south bank of the Nile to Fowera, and on to Buruli. We decided to abandon the last bit of the tour, and set out for Masindi when a day's journey above Fowera, owing to illness, and therefore did not quite reach Buruli.

2. For about ten days before starting on tour, we were employed in interviewing the different chiefs, through whose territory we should pass, and in showing them specimens of the tsetse fly and in talking to them about sleeping sickness. Mr. Wilson had also many talks with them, and had made them promise to cut tracks for us; if this had not been done it would have been almost impossible for us to have gone through the country which we did. The majority of them fulfilled their promises and cut roads for us and helped us considerably in other ways. The Kabaka also helped us by sending some of his headmen with us. These men were invaluable. The chiefs made one stipulation, and that was that no blood-films, &c., should be made. We took some time in explaining and showing them how they were made, but they insisted that if we once began collecting blood or gland preparations, we should find every village we came to deserted, and I have not the slightest doubt that this would have been the case, many of the natives running away as it was.

3. An itinerary of the villages passed during the tour will be found at the end. The tour was made in order to find out :—

(1.) What places were infested by tsetse fly.

(2.) In what places there had been cases of sleeping sickness, and whether the fly was found there as well.

(3.) The nature of the locality in which the fly was found, and any habits of the fly.

(4.) Whether sleeping sickness was increasing or decreasing in those places in which it was known to have occurred.

(5.) If any means could be devised to prevent it spreading across the Victoria Nile by way of the ferry at Fajao, which is much used by traders, &c.

4. Our first camp was at Kajura, 4½ to 5 hours from Hoima; no sleeping sickness there, nor could any fly be found. On the Wachi River there are only a very few natives, and those mostly

old people ; no cases of sleeping sickness. After prolonged search along banks of river two specimens of fly were caught, the only ones seen. There are very few there.

At Daudi's shamba there were also very few people. They said there had been no cases of sleeping sickness there. They knew the fly, but said there were very few there. I saw three only.

Musali's shamba.—No sleeping sickness ; a few flies were caught.

Henery's shamba.—No sleeping sickness ; two flies were caught.

At Bugaki there had been six deaths recently ; two of them were undoubtedly from pneumonia ; one came from Baramweli, possibly sleeping sickness. The other three might have been from sleeping sickness, but the native description of symptoms is not lucid, and they undoubtedly conceal as much as possible. I saw one man who was ill. He was very thin and had enlarged gland in neck ; he permitted me to examine his blood—result negative. It was most probably an early case of sleeping sickness. Many flies were found there. This was close to the Weisoka River.

At Kitembe, close to the Hi-zi-zi River, which runs into the Waiga River, two days from Lake Albert, two flies were found close to the river, but there had been no sleeping sickness there and no deaths during the last year. During the last four months all their dogs had been dying. They had excessive diarrhœa and vomiting and great emaciation ; death in three to four months. They brought me one dog which was very thin ; I took blood-films—result negative. They said that all their puppies had been dying too. They brought me two which they had left. I bought one, which I took along with me ; blood examined, negative, and he is alive and fit up to the present time. Their goats and sheep were well. They had no cattle.

Matumbwa (headquarters of Mwanga), on the Zolia River. The Zolia River is close to the Waiga River, and runs into it just before the latter river runs into the lake.

5. The Waiga along both banks is infested with fly.

6. The following are the villages on the Zolia, in all of which sleeping sickness has occurred :—

Baramweli	7 deaths during last 3 months.
Mutumbwa	5 ,, ,, ,, 3 ,,
Kitchwanti	5 ,, ,, ,, 3 ,,

Villages on the Waiga River :—

Massegi	0 deaths during last 3 months.
Buganna	0 ,, ,, ,, 3 ,,
Matumbwa	5 ,, ,, ,, 3 ,,
Kitagania	6 out of 12 died.
Kiriangandwa	12 ,, 30 ,,
Kiperi	12 ,, 25 ,,
Kiswata	All dead.

Mkondo	All ran away; afraid of sleeping sickness or lions, probably sleeping sickness.
Salizi	50 out of 60 died.
Kibamezi	5 „ 20 „
Buseswa	25 „ 40 „

One of the above places is put as being on two rivers; it is between the two, and quite close to each of them.

7. It will be seen from the above list that there have been a considerable amount of deaths on the Waiga and Zolia Rivers. A good deal of trouble was taken in compiling the above list, different headmen being questioned and their answers being compared to what others had said. Mr. Speke interviewed them again and again, and I think that the above list is as accurate as it is possible to get from natives. I may mention here that we experienced considerable difficulty in getting reliable information from the chiefs and village headmen, and it was only after repeated interviews and questionings that we were able to arrive at any definite conclusions. They all appeared afraid of us at first, and tried to conceal as much as possible. "Sleeping sickness was always in the next village, but never in their own." But, by spending a good deal of time on them, I think we were able to overcome this prejudice or timidness to a very great extent.

Kinyambezu.—Eight deaths out of sixty, according to Mwanga. The headman denied it. Many flies. I saw seven undoubted cases of sleeping sickness.

Kakora.—Population about 100; five deaths during the last three months, two of them due to sleeping sickness; one undoubted case there which I saw. The headman does not think that the cases were infected at home, but considers that the disease in each case was "brought from Bugungu" Very few flies.

Kipesi.—Population 18. Last three months four deaths. No sleeping sickness here. Zoila River about a mile away. The headman said he knew sleeping sickness very well, but that there never had been any in his village. No flies.

Muchunda.—Population 20. One death last three months, probably not sleeping sickness. Headman knew sleeping sickness; no cases of illness there; close to River Nsavia, which runs into Zolia.

Fajao (Okello's).—Population about 30. Okello states that there never has been any sleeping sickness in his village. He was most emphatic; knows the flies, but states they are only found near the Nile; I could find no sleeping sickness and no flies.

Fajao (ferry).—Kiza, the chief, stated that there was no sleeping sickness there and never had been, whereas Okello told me on more than one occasion that there were cases of sleeping sickness there. We found many flies, and the mosquitoes were very troublesome. Found no cases of sleeping sickness there, though we searched the huts. Twenty men allowed me to examine the blood—result negative. I am convinced that there had been cases of sleeping sickness there, but we could find no signs of it, and Kiza most emphatically denied it.

8. We crossed over the river and found fly, but there were no natives there. We then proceeded down stream for two or three miles, and crossed the river; there was a small village about half a mile inland; no sleeping sickness. A few flies on river bank. Headman said he had never heard of sleeping sickness on that side of the river.

9. The inhabitants consisted of fishermen only, so it seems probable that if there had been cases, the infected men would have gone back to their own villages some miles away.

10. On leaving Fajao we went back to Okello's (Fajao), and did our best to get at the root of the matter, but could find no trace of the disease, in spite of several chiefs having repeatedly told us that there were cases there. After leaving Okello's we went to Buyayi, following up the course of the Victoria Nile, but some few miles inland; we were unable to keep along the river bank, owing to the nature of the ground, and the rapids prevented one using canoes. Two rivers were crossed, on the banks of each of which fly was found. The people of Buyayi fetch their water from the Nile as well, and flies were found there, and on the opposite bank no sleeping sickness.

11. At Tanyatiki, our next camp, flies were found; several sick men were examined, but there was no evidence of sleeping sickness.

12. At Gobo we heard the old story of white men killing and eating the natives. The latter, or many of them, evidently believing if a man died in the hospital he was killed and eaten by the Medical Officer in charge. They also in some way connect vaccination with the same idea. The Collector at Hoima informed me that it was difficult to procure labour on that account. We questioned them considerably about this matter, and eventually they brought up a very old man who admitted that he himself had been teaching this doctrine among his own and neighbouring villages. About a year ago a medical officer had been through the old man's village and had found his wife very sick. The medical officer had the woman carried back to the hospital, and in due course sent her back to her husband in good health; on the natives asking why the woman had not died at the hospital and been eaten, the reply was, that she was too fat or too thin. I think there is no doubt that the majority of the natives in that district (Chiopi country) "honestly" believe these stories, even proof like the above failing to shake their belief. From this it will be seen that it is not easy to get at the root *re* sleeping sickness. A few flies, no sleeping sickness and no deaths recently at Gobo. At this place again, we heard that there were cases of sleeping sickness at

Okello's (Fajao) and at the ferry. Mr. Speke at once doubled back, and by making forced marches at night reached Okello's early in the morning, obviously taking the people by surprise. The huts were searched systematically, but no sleeping sickness cases were found. They had evidently removed them some way inland or across the river, and had not yet brought them back. At Tyaki flies were found. The natives denied having had sleeping sickness there. Six sick men were examined by me; one of them might have been an early case of sleeping sickness; glands in part of neck slightly enlarged; very emaciated; no other signs. No deaths during the last year.

Todi.—A few flies; no sleeping sickness; no deaths.

Tanatwaba.—No flies; people all run away.

Fowera.—No flies at first; on third day caught eight.

Koki.—No flies; no case of sleeping sickness at this place.

13. I was laid up with fever, and we decided to abandon the rest of tour and make our way back to Masindi. Nearly the whole of this journey was through low swampy ground; no flies were caught, and no history of sleeping sickness obtained. I had a slight attack of hæmoglobinuric fever when about 35 miles from Masindi, and so did not reach there until October 28th, being carried in by Mr. Jervoise, Assistant Collector.

14. Regarding object of tour:—

(1.) What places were infected with fly?

(1.) See above.

(2.) In what places there had been sleeping sickness, and whether fly was found there as well?

(2.) Places and localities enumerated above for both sleeping sickness and fly; Kakoro being the only place where there was sleeping sickness and in which we were unable to find the fly. This may have been owing to the weather, the day being rather wet and overcast, unless it is more difficult to capture the flies; or it may be due, as the headman said, to the fact that the patients were infected elsewhere.

(3.) The nature of the locality in which the fly was found?

(3.) Always near water, within 250 yards, usually within 50 to 60 yards. A dry river bank with clumps of bushes, trees, and grass about; not as a rule if the grass was very dense, and no scrub. Where there were many trees and it was fairly dry, as in the forest below Fajao, they were plentiful. Where there was papyrus no flies were found near it; also they do not appear to like swampy ground. On the River Waiga there are plenty of flies, also on the Zolia, which runs into the above, but the latter river is swampy in part of its course; tall sword-grass and reeds: no flies were found here. On any of the infested rivers, if they became at all swampy, no flies were found near by. The natives informed me that at this time of the year there are never very many flies to be found; many of them also told me that at times there are very many flies found in the swamps and around. Mr. Dawe, of Entebbe, also told me that he had seen them in numbers close by swamps, and that he had been "bitten" by them while crossing swampy places. I found them always on dry ground with bushes and trees, and also close to water. There are flies on both sides of the Nile below Fajao and above, but the further one gets from Fajao above, the less numerous the flies appear to get. At Fowera there were very few, and above that we found none. This is probably owing to there being more papyrus, and the banks becoming lower and consequently more swampy. There are not so many on the north bank. I think it quite probable that the flies do frequent this locality at certain times of the year. We never found them in banana plantations or in the native shambas. All small streams running into the Nile had fly on them.

(4.) Whether sleeping sickness is on the increase or decrease in the Bugungu district?

(4.) This question is not easy to answer, as undoubtedly many cases were hidden. All the chiefs without exception stated that it was decreasing.

(5.) If any means could be devised to prevent its spreading across the Victoria Nile, by way of the ferry at Fajao?

(5.) A medical officer might be stationed at Fajao, to examine all caravans before they crossed, in order to stop any suspicious case. He would also be in a splendid position for noting habits and peculiarities of the fly, &c., &c.

20. REPORT ON THE ANATOMY OF THE TSETSE-FLY (*GLOSSINA PALPALIS.*)

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The following description is based upon dissections and preparations made in the laboratory of the Sleeping Sickness Commission at Entebbe since my arrival here at the beginning of April. I hope on my return to England to work up my material into a detailed memoir on the anatomy and histology. Time does not suffice for me to complete my work out here, but it seemed worth while, nevertheless, to bring forward as soon as possible a brief description of the general anatomy of the fly, and especially of its digestive tract, on account of its importance for the study of the evolution of the trypanosomes of sleeping sickness, and other tsetse-fly diseases, within the body of their invertebrate host.

In this paper I do not propose to attempt to deal with either the muscular system or the respiratory tracheal system. The former of these is so complex that much more time would be required for working it out than I could afford to spend, and it is, moreover, of little or no importance for the aim in view; while the tracheal system, or at least its finer branches, are so intimately connected with the fat-body, which here, as in other insects, fills up the body-cavity, that in the process of clearing up and laying bare the organs, the tracheæ are for the most part removed. Special muscles or tracheæ will be mentioned in places, but otherwise no account will be taken of these two systems.

The drawings illustrating this memoir are to be regarded as semidiagrammatic, but all details in them have been traced from sketches made with the camera lucida from actual dissections, and therefore claim to be true to nature and accurate as regards scale and proportions. For help in the preparation of these drawings I am much indebted to my colleague, Mr. F. Tulloch, R.A.M.C., who also kindly cut some sections for me. Mr. Tulloch has also made some dissections of *Stomoxys*, comparison with which has thrown light on some points in *Glossina*; Mr. E. Degen, who came out with me, has also helped me in various ways.

Since I have no access out here to any literature or works of reference dealing with insect-anatomy, I am unable to make this account comparative, or to state how far *Glossina* differs from other Diptera as regards internal structure. I shall content myself, therefore, with describing the facts observed by me in a purely objective manner.

In the following description I shall employ the term *waist* for the narrow peduncle connecting the thorax and abdomen, and *neck* for the still narrower connexion between head and thorax.

1. *The Nervous System of Glossina*, as of other Diptera, is concentrated into two masses, one situated in the head, the other in the thorax.

The brain (fig. 1) consists of the two large cerebral ganglia (*S. O. G.*) giving off laterally the still larger optic lobes (*Op. l.*), from which arise the optic nerves. The dissection of the brain and its nerves is rendered somewhat difficult by the large air-sacs, dilatations of the tracheal system, contained in the head. From the anterior side of the cerebral ganglia various nerves are given off: first, a medium nerve of moderate size to the three ocelli (*oc. n.*), arising from the furrow between the two cerebral ganglia, and apparently swelling out into a small ganglion; secondly, a pair of nerves to the antennæ arising about half-way down the front of the brain on each side; thirdly, a pair of small nerves which innervate the muscles of the pharynx, arising near the base of the brain; and lastly, a pair of nerves to the proboscis, which arise from the base of the brain, run forward ventrally to the pharynx, giving off nerves at this point to the muscles of proboscis, and finally enter the bulb of the proboscis, to be distributed to the mouth-parts (fig. 5, *n. p.*).

From the posterior surface of the brain, near its base, the two stout connectives (fig. 1, *Cn.*) arise, and pass down on each side of the greatly narrowed œsophagus, after which they unite almost immediately to form a single broad band of nerve-tissue, which runs back through the neck to join the thoracic ganglion-complex. From this connective band, as it may be termed, there arises, immediately after it enters the thorax, a slender pair of nerves, which form a delicate plexus with the first pair of prothoracic nerves arising a short way behind them (fig. 1, *Cn. n.*).

The connective band often appears distinctly double at its junction posteriorly with the thoracic ganglion-mass, which lies immediately ventral to the proventriculus, the anterior end of the former being a short distance behind that of the latter. It is a mass of considerable thickness in the dorsoventral direction, and appears more or less pear-shaped in a dorsal view, but seen from the ventral side its anterior end appears truncated. When stained, cleared, and mounted in Canada balsam, it is seen distinctly to be composed of three pairs of large ganglia united

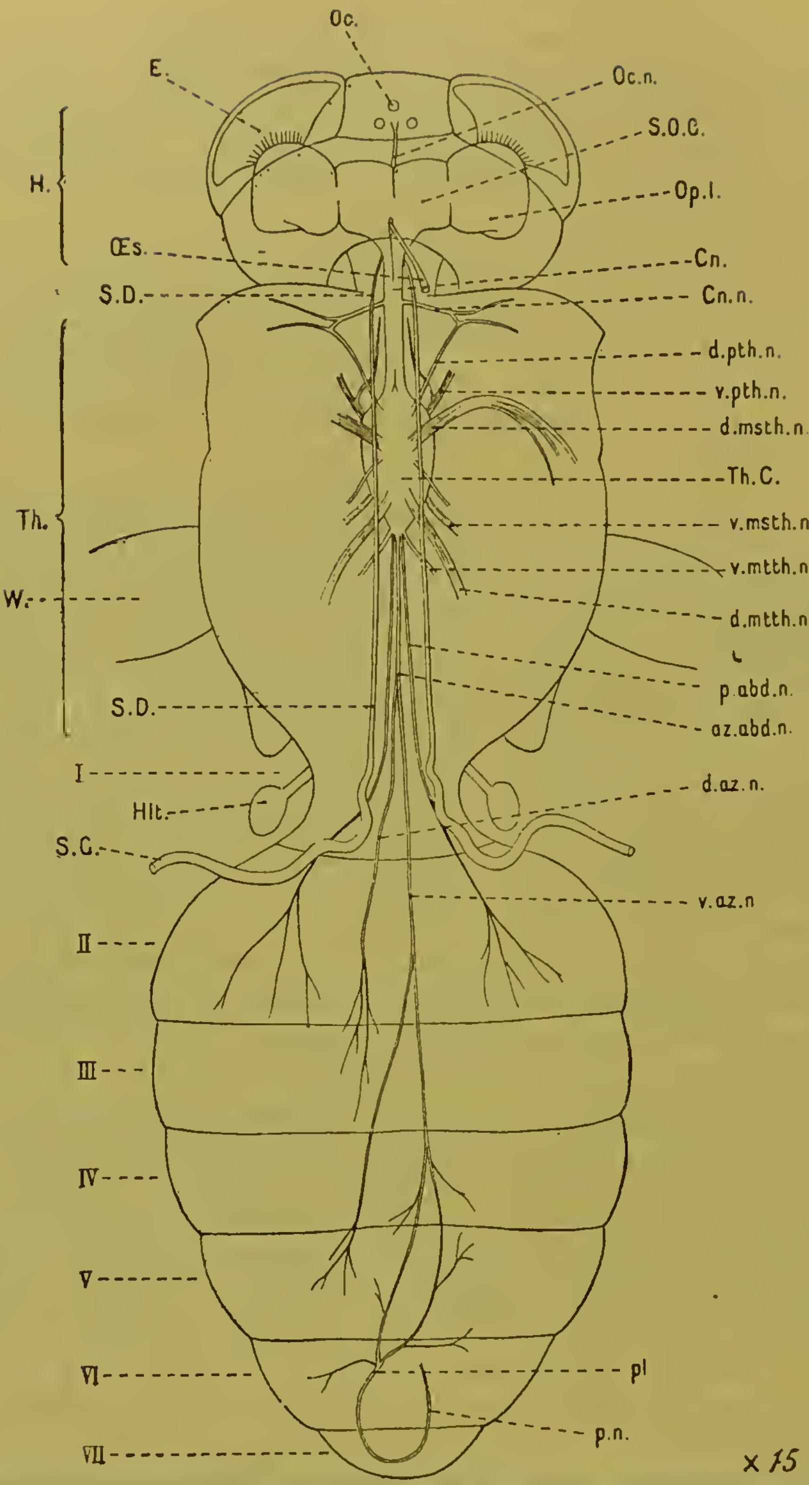

FIG. 1.—General Sketch of the Nervous System, dorsal view. The top of the head is pushed forward and downward as far as possible, to show the brain. A portion of the œsophagus and the salivary ducts are also represented, the salivary gland being supposed to be turned outwards from the abdomen and cut off near the origin of the ducts.

All lettering relating to the nervous system has been placed on the right of the figure, that referring to other parts on the left. *H.*, head ; *Th.*, thorax ; I—VII., the segments of the abdomen ; *Oc.*, ocelli ; *E.*, Eyes ; *Œs.*, œsophagus (cut off) ; *S. D.*, *S. D.*, salivary duct ; *W.*, origin of wings ; *Hlt.*, halter ; *S. G.*, salivary gland ; *Oc. n.*, ocellar nerve ; *S. O. G.*, right cerebral ganglion ; *Op. l.*, right optic lobe ; *Cn.*, connectives ; *Cn. n.*, nerve from the connective forming a plexus with : *d. pth. n.*, dorsal prothoracic nerve ; *v. pth. n.*, ventral prothoracic nerve ; *d. msth. n.*, *v. msth. n.*, dorsal and ventral mesothoracic nerves ; *Th. c.*, thoracic ganglion complex ; *d. mtth. n.*, *v. mtth. n.*, dorsal and ventral metathoracic nerves : *p. abd. n.*, paired abdominal nerve ; *az. abd. n.*, azygos abdominal nerve ; *d. az. n.*, dorsal branch of the azygos nerve ; *v. az. n.*, ventral branch of the azygos nerve (genital nerve) ; *pl.*, plexus formed by the genital nerve ; *p. n.*, nerve to penis.

together, corresponding to the three segments of the thorax, behind which a small mass of ganglion-cells, representing the abdominal nervous system, forms the posterior-pointed termination of the thoracic complex.

From each of the thoracic ganglionic centres arise two nerves, one dorsal and one ventral, so that altogether six pairs arise from the body of the thoracic complex, which are distributed to their proper regions of the thorax. From the posterior end of the thoracic complex arise three nerves, one medium unpaired, and two lateral paired, which pass backwards into the abdomen.

The greater part of the thorax of the fly is a mass of muscle, and as the muscles have to be removed in order to display the other organs in the thorax, the terminations and finer branches of the nerves are torn away from them. Hence it is impossible to describe accurately the destinations of these nerves without a detailed study of the musculature, which, as already stated, I have not made. It would appear, however, that the three ventral pairs of thoracic nerves innervate the legs and their muscles.

The dorsal prothoracic nerves (fig. 1, *d. pth. n.*) are very slender, and, as already stated, form anastomosis with the nerves from the connectives. The ventral prothoracic nerves (*v. pth. n.*) are of moderate size.

The dorsal mesothoracic nerves (*d. msth. n.*) are very large, being in fact the stoutest nerves in the body. They run slantingly forward, then curve round till they run in a backward direction, and appear to be distributed to the wing muscles. A small nerve arises from the ganglion close behind the origin of the dorsal mesothoracic nerves, and runs backwards in a dorsal direction. It is drawn in fig. 1, but not lettered, and is probably to be regarded as a branch of the dorsal mesothoracic nerve. The ventral mesothoracic nerves (*v. msth. n.*) are also of fairly large size.

The dorsal metathoracic nerves (*d. mtth. n.*) are large, the ventral ones (*v. mtth. n.*) of moderate size.

The three abdominal nerves run at first straight backwards, and almost parallel to each other, to the waist. Before reaching it the median nerve (*az. abd. n.*) has divided into a smaller dorsal and a larger ventral branch. After passing through the waist the two lateral nerves (*p. abd. n.*) diverge outwards to the sides of the abdomen and break up into numerous branches.

The dorsal branch of the median nerve is distributed to organs situated dorsally in the abdomen. The ventral branch of the median nerve is the nerve of the generative organs. In the male I have found that its branches unite to form a plexus (fig. 1, *pl.*) apparently containing a small ganglion, which gives off nerves in various directions, and from which a fairly stout nerve (*p. n.*) arises and follows the ductus ejaculatorious in its tortuous course, till it finally enters with it the penis, the muscles of which it innervates. In the female a similar plexus appears to be formed, but owing to the dense tangle formed by the fat-body, uterine glands, and Malpighian tubules, I have not succeeded in dissecting out its finer details.

2. *The Digestive Tract.*—Since the proboscis, buccal cavity, and pharynx have been thoroughly described in Austen's monograph by Hansen, whose account I can but confirm, I commence my description with the œsophagus. This portion of the alimentary canal (figs. 1 and 2, *Œs.*) runs first of all in an upward direction from the pharynx (*Ph.*), then bends sharply round and passes backwards through the brain. The first portion of the œsophagus is dilated, but slightly compressed, appearing of greater calibre in a dorsal than in a lateral view. After bending round, it narrows rapidly, and the portion which passes through the brain is of extreme tenuity, scarcely, if at all, of greater calibre than the salivary ducts. Behind the brain the œsophagus widens, at first very gradually, then, after entering the thorax, more rapidly, till it joins the proventriculus, into which it opens ventrally, breaking through the floor slightly in front of the point at which the thoracic intestine arises dorsally. From the point at which the œsophagus opens into the proventriculus, the duct of the sucking stomach arises.

The proventriculus, which marks the commencement of the mesenteron, has a peculiar and very characteristic form (fig. 2, *St.*). Seen from the dorsal aspect, it appears roughly oblong in form, with a bevelled anterior edge, and the upper surface more or less saddle-shaped, *i.e.*, convex in the transverse section, concave in the longitudinal direction. Seen from below, its lateral edges appear wrapped round the œsophagus and the duct of the sucking stomach, on which it rides, as it were. From the dorsal side of the proventriculus, about the middle of its length, arises the intestine, the first part of which (*Th. I.*) runs backwards through the thorax as a straight tube of even calibre, until it passes the waist. As soon as it enters the abdomen the intestine swells and becomes the strictly digestive portion of the alimentary canal.

The abdominal intestine is of great length, but until it reaches the proctodæum it cannot be divided into regions. It forms a number of complicated coils in the abdomen, and for purposes of description a number of limbs may be distinguished, each limb separated from the one next following by a more or less sharp bend (figs. 2 and 3).

The first limb (1) runs backwards along the abdomen in a dorsal situation, curving first slightly to the right, then more strongly to the left, until it reaches the fifth segment, where a sharp bend takes place forwards in a ventral direction. The

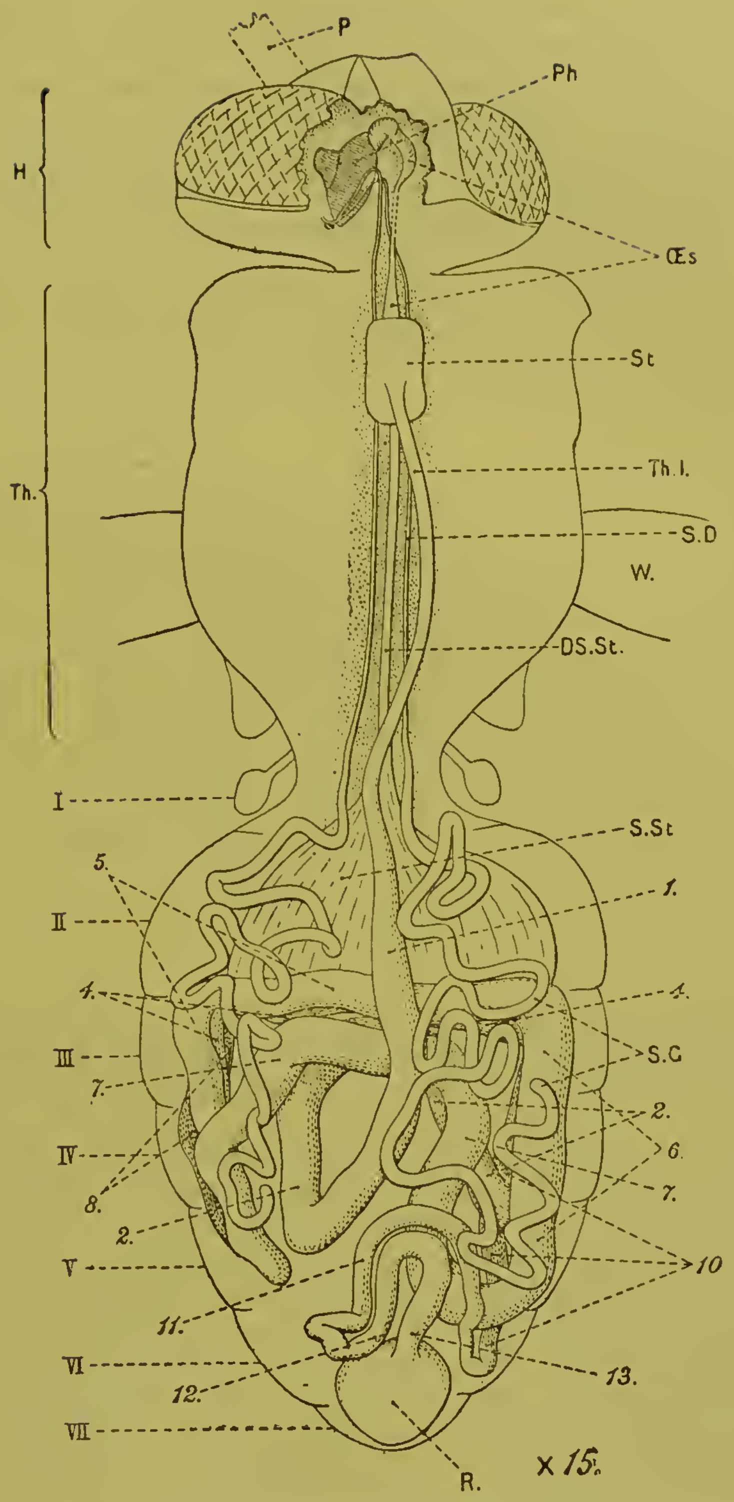

FIG. 2.—General View of the Digestive Tract, as seen in dorsal view without disturbing its parts. The heart and overlying tracheæ and fat-body are removed in the abdomen, also the muscles in the thorax, and the brain and other parts of the nervous system are omitted from the drawing. The head is turned round to the left, in order to shew the pharynx, etc., in three-quarter side view.

Ph., pharynx; *Œs.*, œsophagus (the portion which passes through the brain being represented with a dotted outline); *St.*, proventriculus; *Th. I.*, thoracic intestine, pulled over to the right, in order to shew the duct of the sucking stomach lying beneath it; *S. D.*, salivary duct; *D.S. St.*, duct of; *S. St.*, the sucking stomach; *S. G.*, salivary gland (that on the right is drawn from a specimen in which the gland was more developed than in the case of that drawn on the left); 1—13, limbs of the abdominal intestine (see fig. 3): *R.*, Rectum. Other letters as in the preceding figure.

second limb (2) curves round from left to right, running first anteriorly, then transversely, and lastly in a posterior direction. It is more ventral in situation, being placed below some of the succeeding coils. The third limb (3) is short, and runs straight forward on the right side from the fifth to the third segment. Not visible in fig. 2, its position is indicated in fig. 3. The fourth limb (4) turns at right angles, and runs transversely across

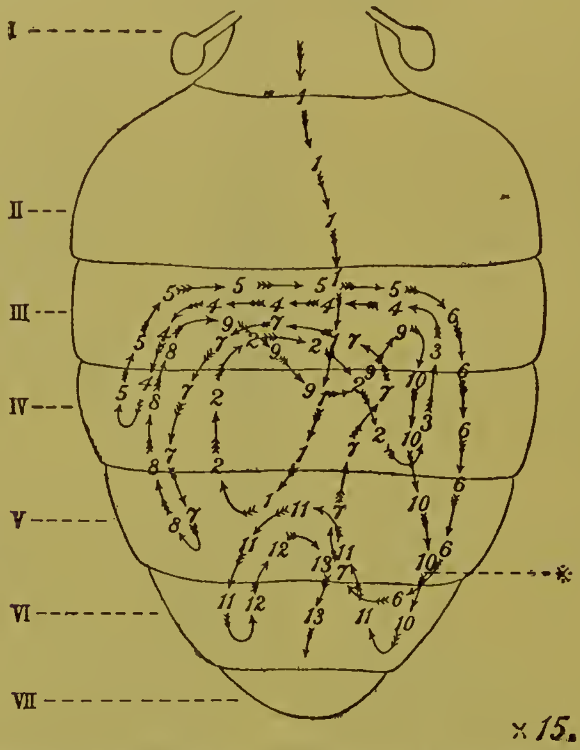

Fig. 3.—Diagram to show the various limbs (1–13) of the abdominal intestine, and their arrangement in the abdomen. The asterisk * denotes the point at which the Malpighian tubules arise in the tenth limb.

the body in the third segment, passing back a short distance into the fourth. The fifth limb (5) turns sharply back on the fourth and runs dorsally to it across the body again in the third segment. The sixth limb (6) turns back at a right angle and runs back on the right side of the body from the third to the sixth segment. The seventh limb (7) turns sharply forwards, then curves round in a roughly semi-circular course in the third segment, and finally runs backwards on the left side as far as the fifth segment. The fifth, sixth, and seventh limbs form together a well-marked loop, lying superficially, which is generally the most dilated portion of the intestine and represents the true stomach. The eighth limb (8) bends sharply forwards and downwards, and runs deep on the left side from the fifth to the third segment. The ninth limb (9) bends at right angles and runs at first transversely in the third segment, then curves back into the fourth, then forwards again into the third segment. The tenth limb (10) runs backwards along the right side of the body from the third to the sixth segment, and in the fifth segment gives off the Malpighian tubules (*, fig. 3), so that from this point the gut must be regarded as proctodæum. The eleventh limb (11) runs from right to left in a semicircular curve occupying the fifth and sixth segments. From the origin of the Malpighian tubules to the end of the eleventh limb the gut is of small calibre, and may be called the ileum. The succeeding portion is thicker, and may be called the colon. It lies in the fifth and sixth segments, and forms the twelfth and thirteenth limbs (12, 13), both short and sharply bent one on the other. The ileum and colon lie dorsally in the body, and the colon passes into the capacious rectum (*R.*), which has four rectal glands (fig. 5, *r. gl.*) each supplied by a bunch of small tracheæ.

The appendages of the digestive tract are the salivary glands, the sucking stomach, and the Malpighian tubules.

The salivary glands (fig. 2, *S. G.*) commence, starting from their distal ends, as two long tubes, much coiled, and occupying a very superficial dorsal position in the abdomen on each side of the heart, above the alary muscles. Very transparent in the fresh condition, the salivary glands become glistening white in colour when put in alcohol. Only tracheæ and fat-body come between them and the dorsal body-wall. The coils of the tubes extend back as far as the fourth or fifth abdominal segment, but the distal extremity of the gland may lie further forward than this. With many twists and turns the tubes run forward to the waist and then pass into the thorax, at the same time diminishing rapidly in calibre, straightening out their coils, and descending to the ventral side of the body. From this point the salivary gland becomes the salivary duct (figs. 1 and 2, *S. D.*). The two ducts run a parallel course through the thorax, on a level with the duct of the sucking stomach, and on each side of it, passing under the proventriculus and above the thoracic glanglion (figs. 1 and 2). When they reach the neck, the salivary ducts become so extremely attenuated that their course through the head is very difficult to follow. As they enter the neck the ducts curve over towards each other, and pass under the connective nerve-band, thus parting company from the œsophagus, which passes above the connective. The ducts pass under the brain and then under the pharynx.

If the head of a fly be examined from below, there will be found, immediately behind the bulb of the proboscis, an area covered by soft flexible integument, which recalls the soft skin at the base of a parrot's beak, and has a similar function, that is to say, to allow free play for the movements of the proboscis. When the proboscis is bent down, in the attitude it assumes when the fly is drawing blood, the soft skin forms a fold over the bulb, and when the proboscis points forward, in the attitude of repose, enclosed in the sheath formed by the two palpi, then the soft integument is stretched. If this flexible skin be removed, a cavity is exposed lying below the pharynx (fig. 4, *Ph.*) across which run the nerves to the proboscis (*n. p.*), a pair of retractor muscles uniting anteriorly (*r. m.*) and the two delicate salivary ducts (*S. D.*). The last-named remain perfectly distinct and separated from one another until they pass dorsally to the median muscle formed by the two united retractors. A stained preparation, which I have cleared and mounted in Canada Balsam, shows the two ducts uniting into a single duct above this muscle. In *Stomoxys*, according to Hansen's description, the two salivary ducts unite into a median duct much further back than I have found to be the case in *Glossina.* Hansen, it may be noted in passing, speaks always of the thoracic salivary gland,* but in *Glossina* these glands are not thoracic, and in *Stomoxys* they are partly abdominal. The immensely powerful muscles of flight, filling up the thorax, are probably the cause of the glands being shifted back into the abdomen. To follow the further course of the salivary duct after it enters the proboscis, sections would be required, which I have not made, since Hansen has already described the duct as opening on the hypopharynx, as in all other insects.

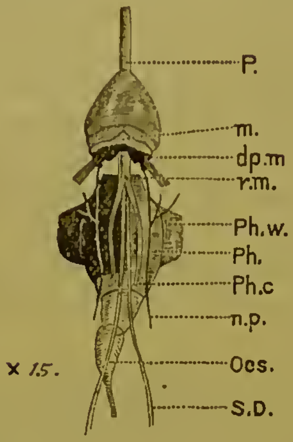

Fig. 4.—Dissection of Pharynx, Proboscis, Salivary Ducts, etc., ventral view.

P., proboscis; *m.*, soft integument cut away behind the bulb of the proboscis; *dp. m.*, depressor muscle of the proboscis; *r. m.*, retractor muscles; *Ph.*, pharynx; *Ph. w.*, chitinous wings of the pharynx; *Ph. c.*, membranous continuation of the ventral wall of the pharynx, to which the retractor muscles are attached; *n. p.*, nerve to the proboscis; *Œs.*, œsophagus; *S. D.*, salivary duct.

The sucking stomach is morphologically a ventral diverticulum of the hinder end of the œsophagus, which is placed in the two anterior segments of the abdomen, its connection with the œsophagus being drawn out into a long slender duct traversing the thorax. The sucking stomach in the ordinary condition of the fly is filled with gas, but shortly after feeding it is found filled with blood.

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* Austen also states ("Monograph," p. 35) that "the salivary gland [of Diptera] . . . is always situated in the *thorax*." (The italics are Austen's.)

The duct of the sucking stomach arises, as already stated above, from the œsophagus, at the point at which the latter communicates with the proventriculus, in such a way as to appear as a direct continuation of the œsophagus, the opening into the proventriculus having rather the appearance of a dorsally-directed diverticulum. At the point where the communication with the proventriculus occurs, the sides of the proventriculus are folded down ventrally so as to wrap completely round the duct, meeting below it, and froming a complicated system of cavities into which the fat-body intrudes.

When the duct passes the waist, it expands rapidly to become the capacious sucking stomach (figs. 2 and 5, *S. St.*), which has delicate walls, provided with a layer of striped muscles disposed irregularly.

The Malpighian tubules (*M. t.*, *M. t.*, fig. 5) arise by a pair of main stems given off from opposite sides of the 10th limb of the abdominal intestine. Each of these stems very soon divides into two again. In *Glossina* these tubules are excessively long, and so entangled with the fat-body and other organs that it is impossible to unravel them for their whole length, but since they are never observed to branch again, after their origin from the two main stems, it may be inferred that, as in other Diptera, there are in all four Malpighian tubules, disposed in this case in two couples, each couple coming off from a common stem. When the dorsal integument of the abdomen is removed, it can generally be observed without difficulty that two of the Malpighian tubules have thickened terminations, which lie close alongside the heart in the pericardial sinus right and left. In some specimens of *Glossina* these two tubules are not conspicuously thickened, but their position is constant. In no case do they exceed the salivary glands in thickness. It is evident that these two tubules must be of physiological importance for purifying the blood in the pericardial sinus. Mr. Tulloch has found in *Stomoxys* the same two pericardial Malpighian tubules, thickened to such an extent as to greatly exceed in calibre the salivary glands. Mr. Tulloch also found, and I was able to confirm his observation, that the two pericardial tubules of *Stomoxys* were a couple, arising both from one of the two stems on one side of the gut. The Malpighian tubules being much shorter in *Stomoxys* than in *Glossina*, it was possible to dissect out the two pericardial tubules of the former as far as their common origin from the gut, at which point they were detached, stained, and mounted in Canada Balsam, thus putting this somewhat unexpected result beyond all doubt. Whether the two pericardial Malpighian tubules of *Glossina* are also, like those of *Stomoxys*, a couple with a common origin, cannot be stated with complete certainty, but it seems at least highly probable.

The morphological significance of this fact is, perhaps, that the two common stems of the Malpighian tubules are not to be considered as arising right and left from the gut, but as dorsal and ventral in origin. I have not succeeded in finding the distal extremities of the two remaining tubules, but they appear to pass down towards the ventral side of the abdomen and to be entangled with the genital organs, the dissection of which they help to render difficult.

3. *The Genital Organs* lie in both sexes close to the ventral side of the body in the hinder segments of the abdomen.

The male organs (fig. 5) consist of two pairs of tubes, greatly convoluted for a whole or a part of their course, which open all together into an unpaired tube, the ductus ejaculatorius, which in its turn passes to the external organs of generation and opens on the penis.

Commencing with the paired portions of the male apparatus, it is observed that the two tubes on either side differ markedly from one another. One pair, placed most posteriorly, is tightly wound and has the coiled portion pigmented. The other pair, more anterior, forms a looser coil and is without any pigment. I identify the former as the testes, the latter as the vesiculæ seminales.

Each testis commences with a delicate white filament (*t. f.*), embedded in the fat-body and difficult to trace. I have not succeeded in finding where the free end of the filament is attached; in dissections it appears to be loose. The filament passes on into the tightly coiled pigmented tube, which forms a conspicuous, compact, brown body, the testis (*T.*). In one dissection I succeeded accidentally in uncoiling the testis by pulling inadvertently on the filament when trying to remove the fat-body. It was then seen that each testis is a whitish coiled tube enveloped in a pigmented brown coat, which crumbles easily into a brown powder. In specimens that have been long in alcohol also the pigmented coat often sticks to the surrounding fat-body and comes away from the testis. The proximal part of the testicular tube is dilated and forms the testis proper; the distal portion is of smaller calibre and more tightly coiled, forming an epididymis, from which the tube is continued as the vas deferens (*V. d.*). The latter is a white, straight, or but slightly sinuous tube. The brown pigment of the testis is continued a very short way down the vas deferens, and ends abruptly.

Each vesicula seminalis (*V. s.*) is a white tube, commencing with a blind end. A short distance from the commencement the tube is slightly thickened for a short distance. There is nothing to bind the coils together, nor any pigment, as in the testis. Distally the tube straightens out to open into the unpaired duct of the generative system.

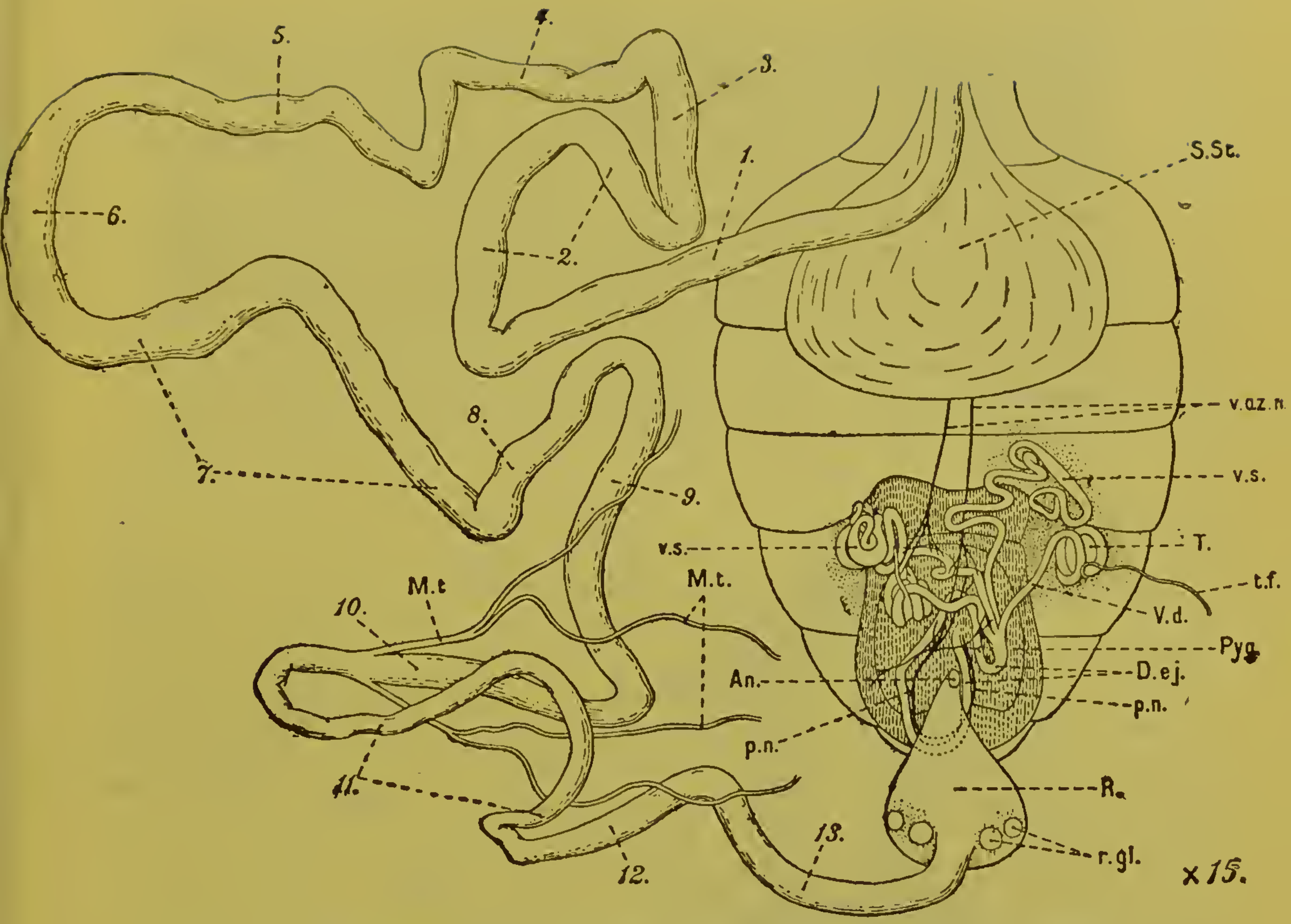

FIG. 5.—Dissection of the Abdomen, showing the Abdominal Intestine unravelled and turned over to the left side, and the Male Genitalia *in suti* in the Abdomen.

S. St., sucking stomach ; 1—13, the limbs of the intestine, as indicated in the two previous figures ; *M. t.*, *M. t.*, Malpighian tubules ; *R.*, rectum ; *r. gl.*, rectal glands ; *An.*, anus ; *T.*, testis ; *t. f.*, testicular filament ; *V. d.*, vas deferens ; *v. s.*, *v. s.*, vesiculæ seminales, that on the left in its natural coil, that on the right unravelled ; *D. e. j.*, ductus ejaculatorius ; *Pyg.*, hypopygium ; *v. az. n.*, branches of the ventral azygos nerve (genital nerve) ; *p. n.*, nerve to penis, following the ductus ejaculatorius.

The ductus ejaculatorius (*D. ej.*) has at its commencement a slight dilatation, into which open the four tubes just described. From this point the ductus runs a very short way backwards, then curves sharply forwards, but soon turns back again, passes across to the left side of the body, and forms a loop round the rectum, coming forward on the right to pass into the penis.

The various parts of the male generative organs are innervated, as already described, by a nerve plexus formed from the azygos abdominal nerve. There appears to be a small ganglionic swelling on the doctus ejaculatorious, whence arises a nerve (*p. n.*) which follows the ductus in its course to the penis.

The external organs of generation are concealed beneath the hypopygium. The penis is an organ of complicated structure and mechanism, with an armature of hooks, spines, hairs, and semaphore-like erectile flaps, which would require so many figures to make their arrangement and relations clear, that I refrain at present from attempting any description of them.

The female genital organs differ considerably in appearance according as they are in the gravid or non-gravid condition. In the course of my dissections I have only found one female in the latter state. In the later periods of gestation the condition of the female is obvious externally, but females which do not appear to be gravid are found on dissection to have a small larva in the uterus.

The female organs (fig. 6) consist, like the male, of paired and unpaired portions. The former comprise the ovaries, the receptacula seminis and their ducts, and the uterine glands; the latter are the oviduct, uterus, and vagina. The female system of organs is considerably modified from the condition usually found in insects, in relation to the fly's peculiar method of reproduction.

FIG. 6

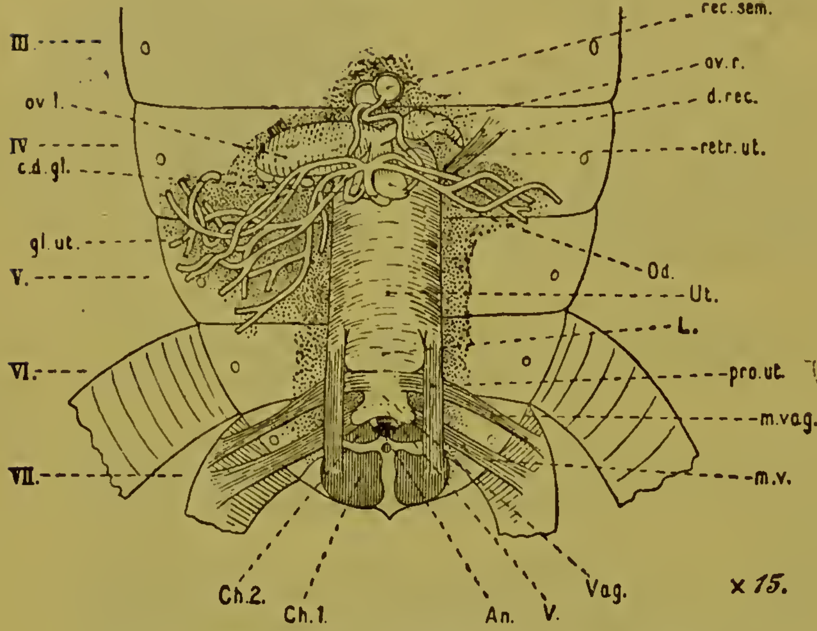

FIG. 6.—The Hinder Segments of the Abdomen with the Female Genital Organs *in situ*, dorsal view.

rec. sem., receptacula seminis; *ov. r.*, *ov. l.*, right and left ovarioles; *d. rec.*, duct of the right receptaculum seminis; *gl. ut.*, uterine glands (the greater number of these have been removed); *c. d. gl.*, their common duct; *retr. ut.*, retractor muscle of the uterus; *Od.*, oviduct; *Ut.*, uterus; *L.*, hinder extremity of the larva, causing a bulge in the uterus; *pro. ut.*, protractor uteri, attached to the chitinous plate (*Ch.* 1); *m. vag.*, muscle (dilator vaginæ ?) passing from the vagina to the tergum of the seventh abdominal segment; *m. v.*, muscle passing from the paired chitinous plate (*Ch.* 2) on each side of the vulva to the seventh tergum; *Vag.*, vagina; *V.*, vulva, the anterior margin of which is shown by a dotted line; *An.*, anus; *Ch.* 1, *Ch.* 2, paired chitinous plates.

FIG. 7.

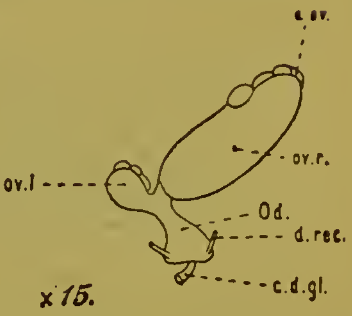

FIG. 7.—The Ovarioles and Oviduct of a Non-gravid Female.

a. ov., apex of right ovariole; other letters as in the preceding figure. The very large ovum in the right ovariole has pushed the oviduct over towards the left side of the body.

The ovaries are reduced to a single pair of ovarian tubes or ovarioles, one on each side of the body (figs. 6 and 7, *ov. r.*, *ov. l.*). Each ovariole shows only a small number of egg-chambers, not more than four or five. The lowest chamber is very much larger than any of the others, and contains a large ovum. When this ovum is comparatively small, the other egg-chambers are in a line with it (fig. 6, *ov. r.*), but as the ovum grows larger it grows past the other egg-chambers, so that they appear attached to the side of the ovum (fig. 6, *ov. l.*, fig. 7, *ov. l.*, *ov. r.*).

The two ovarioles are always asymmetrical, owing to the fact that the ova in the lowest egg-chambers reach full growth on each side alternately, so that if there is a large ovum on the left, there will be a smaller one on the right, and *vice versâ*. The largest ovum I have seen was from a non-gravid female (fig. 7, *ov. r.*), and was probably nearly, if not quite, full-sized.

The two ovarioles open into the short, broad oviduct (figs. 6 and 7, *od.*), which widens out at its lower end to open into the uterus slightly behind the proximal end of the latter.

At its distal expanded end the oviduct receives right and left the two ducts (*d. rec.*) of the receptacula seminis. The latter (*rec. sem.*) are small spherical bodies of a bright orange-yellow colour, surrounded by a whitish, transparent envelope. Examination of the receptacula stained and mounted in Canada balsam shows that the clear envelope is an epithelium of large cells, surrounding a thick chitinous membrane which gives these organs their peculiar colour, and which is too opaque for the contents to be seen except in sections, by which method the receptacula are seen to be filled with spermatozoa. The two receptacula are firmly attached to one another. From each comes off the slender white duct, slightly convoluted. The ducts are perfectly distinct from one another, and open, as described above, into the lower end of the oviduct.

Immediately below the opening of the oviduct into the uterus, a small tube debouches into the latter by a median dorsal aperture. This is the common duct of the uterine glands (figs. 6 and 7, *c. d. gl.*). After a short course it branches right and left into tubes, which branch again repeatedly, forming a great number of glandular tubes, which differ markedly in the gravid and the non-gravid condition. In the latter state the gland-tubes are relatively few and very slender. In the gravid condition, on the other hand, the tubes are very numerous, forming a tightly packed mass filling up the posterior end of the abdomen, and requiring to be pulled away to show the other parts of the generative system; further, the individual tubes are much thicker, and when stained and mounted, they take up the stain very deeply and appear very opaque. There can be no doubt that these glands serve for the nourishment of the larva in the uterus.

The uterus (*Ut.*) is a large thimble-shaped organ attached to the body-wall by a number of muscles. Two retractors (*retr. ut.*)

run forwards from the proximal end. There are two pairs of protractors, one dorsal, the other ventral; the former (*pro. ut.*) start from the sides of the uterus and pass backwards to a pair of chitinous plates (*Ch.* 1) at the posterior end of the body. The wall of the uterus is beset by a very large number of small tracheal tubes (not shown in the figure), and is thick in the non-gravid condition, but becomes thinner when stretched by the growth of the contained larva. In all gravid uteri that I have seen, the two papillæ at the hinder end of the larva cause a bulge in the lower end of the uterus (fig. 6, *L.*). When the larva reaches a certain size, the rings of its segments become plainly visible through the wall of the uterus; they could not be seen in the uterus drawn in fig. 6, but in another, slightly larger, they could be seen distinctly.

The vagina (fig. 6, *Vag.*) is a broad tube, considerably longer in the non-gravid than in the gravid condition, with a pair of dilator muscles (*m. vag.*) which are attached right and left just below its junction with the uterus, and pass outwards to be attached to the anterior margin of the tergum of the seventh abdominal segment. The vagina widens out slightly as it approaches the vulva (*V.*), which is a crescentic, transversely elongated aperture, separated from the anus by a small chitinous plate (*Ch.* 2), one of a pair from which two muscles (*m. v.*) arise and pass outwards to be attached to the seventh tergum, a little way behind the attachment of the vaginal muscles already mentioned. These muscles probably act as dilators of the vaginal aperture, and the five pairs of muscles described in the preceding lines are to be regarded as constituting the mechanism of parturition.

4. *The Vascular System* consists of the heart, in the abdomen, and its continuation, the thoracic aorta, in the thorax.

The heart occupies the five anterior segments of the abdomen, and is situated dorsally immediately below the plates of the terga. It is so imbedded in the fat-body and pericardial tissue that not much can be made out of its structure by dissection alone, and examination of it mounted as a preparation for the microscope is necessary. It can then be seen to have five chambers, each with a pair of ostia and a pair of alary muscles, corresponding to the segments in which it lies. The alary muscles pass out at right angles to the axis of the heart, and can be traced through the fat-body to their attachments at the external laternal margins of the tergal plates.

The hindermost chamber of the heart appears to end blindly posteriorly. A little way in front of the hinder end are attached the two large alary muscles, the largest of the whole series; not far in front of these again are the two ostia, on the sides of the widest part of the chamber. In front of the ostia the lumen of the heart narrows rapidly, and to the narrowed portion is attached the next pair of alary muscles, lying in the hinder part of segment IV. This arrangement is continued in segments II., III., and IV., the dilated portion of the chamber, with the ostia, occupying the middle of the segment, while the alary muscles, attached to the constrictions between the chambers, lie in the posterior regions of the segments. The alary muscles of these three segments are of moderate size. In segment II. the heart receives a pair of tracheal tubes, right and left, which come to it opposite the ostia, and fork at once into branches running forwards and backwards. The alary muscles corresponding to the first abdominal segment are very small and difficult to make out, and the region of the heart to which they are attached does not show the slightest diminution or constriction of its lumen, as is the case in all the chambers posterior to it. In front of the first pair of alary muscles, at the usual interval, are the two ostia, quite similar to those of the other chambers. In front of the first pair of ostia the lumen of the heart narrows to form a thin-walled vessel, which passes through the waist to become the artery which I have termed above the thoracic aorta. This last runs along the thoracic intestine on its dorsal side, and is continued over the proventriculus, remaining apparently quite independent of the digestive tract, and only loosely attached to it, until it reaches the œsophagus. Here it is firmly attached and becomes considerably dilated. A short distance in front of the proventriculus a conspicuous cushion-like mass of large cells lies over the aorta. At first I took this structure for a ganglion, but it appears to be a sort of lymphatic gland, judging from its appearance in sections. The thoracic aorta is apparently continued through the neck into the head, but I have not been able to follow its course further than the thorax.

The microscopic examination of the heart shows further that its floor is composed chiefly of fusiform cells resembling unstriped muscle-fibres, while its sides are made up of gigantic cells with nuclei of corresponding proportions. These cells are arranged with perfect regularity, and in a manner exactly similar on the two sides of the heart. Each ostium is formed by two cells, which are of small size when compared with the huge cells building up the wall of the heart, but are very large when compared with the cells of the surrounding tissues. Two of the giant cells intervene on each side between the hinder end of the heart and the fifth pair of alary muscles ; two more between these muscles and the ostia next in front of them ; and so on with unfailing regularity all the length of the heart, each ostium being separated from the alary muscles next in front or behind by just two giant cells. In front of the first pair of ostia are found two cells of the usual size on each size, then a pair of slightly smaller cells, which pass on into the walls of the thoracic aorta. Thus, not counting the ten couples of smaller cells which compose the five pairs of ostia, the entire wall of the heart is built up of 23 pairs of giant cells ; to wit, four pairs to each of the five chambers, two additional pairs behind the fifth pair of alary muscles, and one pair anteriorly, making the transition to the thoracic aorta.

In view of the fact that the thoracic vessel is itself to be considered as a modified anterior portion of the heart, it is interesting to find that its delicate wall contains very large, flattened nuclei, arranged in pairs, right and left.

The alary muscles consist of delicate fibrils, arranged in an irregular fan-like manner, uniting into a stout muscle-fibre which is distinctly striated.

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21. *GLOSSINA PALPALIS* IN ITS RELATION TO *TRYPANOSOMA GAMBIENSE* AND OTHER TRYPANOSOMES (*Preliminary Report*).

By E. A. Minchin, M.A., Professor of Protozoology in the University of London, Lieut. A. C. H. Gray, R.A.M.C., and the late Lieut. F. M. G. Tulloch, R.A.M.C. (Sleeping Sickness Commission).

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[Plates 1–3.]

In this paper we propose to give a brief statement of the results obtained by us with reference to the relation of the tsetse-fly (*Glossina palpalis*) to the trypanosome of sleeping sickness (*Trypanosoma gambiense*), and to other species of trypanosomes which this fly carries.

Our investigations have consisted of observations and experiments upon (A) Flies fed in the laboratory on animals which had been infected by the inoculation of cerebro-spinal fluid from sleeping sickness patients, and which showed trypanosomes in their blood as the result of such inoculation. (B) Flies caught in various localities which were found on dissection to contain trypanosomes in their digestive tracts.

Of the trypanosomes under the latter heading (B) we have found two distinct types. One of these types has been named by Professor F. G. Novy* *Trypanosoma grayi*, and one of us (Professor E. A. Minchin) proposes to call the other type *Trypanosoma tullochii.*

Type I. *T. tullochii*, n. sp. Minchin.—This type is distinguished by its more rounded nucleus placed near the middle of its body, by a small, usually circular, blepharoplast placed well behind† the nucleus, *i.e.*, at the end furthest from the flagellum (Plate 3, figs. 53–60).

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* "Journal of Infectious Diseases," vol. 3, No. 3 (May, 1906), pp. 394–411, Plates 15–17. Professor Novy gives some excellent microphotographs of these trypanosomes, taken from preparations sent him by Lieutenant Gray.

† In this memoir we use the terms anterior and posterior purely with reference to the direction of locomotion of the trypanosomes described by us, and without prejudice to the disputed morphological questions involved.

Type II. *T. grayi*, Novy.—This form is characterised by its large nucleus, which may be oval, spherical, or compressed, and which is in all cases situated not far from the posterior end of the body. In many cases the nucleus shows distinctly eight chromosomes. The blepharoplast is large, transversely elongated, and situated close to the nucleus, either at its side or more usually anterior to it. Sometimes, however, it may be posterior to the nucleus, a point which we discuss further below. The flagellum is often distinctly thickened at the tip. This type varies very greatly both in form and size. We distinguish (1) male forms, very slender, with long free flagellum, with nucleus very compressed, and with the blepharoplast situated in front of it (Plate 2, figs. 21 and 22). Some of the forms reach an extraordinary length (Plate 2, fig. 33). (2) Female forms which are bulky, often thickened at the posterior end and with an oval or rounded nucleus. The blepharoplast is variable in position, and the free flagellum is very short (Plate 2, figs. 23–25 and 34). (3) Young forms (Plate 2, figs. 31 and 32) and indifferent forms, varying greatly in character; among the latter we may particularly note forms which are nearly spherical (Plate 3, figs. 43–51). The very protean character of these forms (*see* Plate 2, figs. 35–40; Plate 3, figs. 41–52) make it very uncertain as to whether they are really all of the same species. Since, however, we have noticed a marked difference between trypanosomes from flies which had fed after being caught and those in flies that had not fed (Plate 2, figs. 33 and 34, and Plate 3, fig. 41), we think that these variations of type are to be explained as the result of the conditions of nutrition of the host. The forms from flies which had not been fed were both scarcer and larger than those from flies which had recently sucked blood. In flies dissected soon after feeding it was found that small forms (Plate 2, figs. 31 and 32) largely predominated, and dividing forms were numerous (Plate 2, figs. 27, 28, and 29); on the other hand, in those cases in which flies were found to contain forms of a more indifferent character (Plate 2, figs. 36–40), it was noticed that stages of division were extremely rare, and that aggregations of similar forms into large masses were frequent (Plate 3, fig. 42).

The mode of division in *T. grayi* is noteworthy and characteristic. The two sister individuals which result from it are markedly unequal in size and differ also in the relations of their nucleus and blepharoplast. The smaller of the two has the blepharoplast placed in what may be considered the normal position, that is to say, well in front of the nucleus. On the other hand, the larger individual has the blepharoplast placed behind the nucleus (Plate 2, fig. 28). We consider, therefore, that the forms not infrequently found, in which the blepharoplast is situated behind the nucleus, represent, in many cases at least, the larger of two sister individuals resulting from recent division. Multiplication by division has only been observed by us in individuals of indifferent or female type, never in fully differentiated male forms. Finally, we may draw attention to the numerous chromidia always present in young, indifferent, or female forms. In their staining reactions the chromidia seem to resemble the blepharoplast more than the nucleus.

(A) *Observations and Experiments with Flies Artificially Infected with* T. gambiense.—We undertook very numerous experiments to determine the exact mode of infection by the fly, particularly with the object of determining whether the fly became infectious at any definite period after having been fed on an infected animal. For instance, a batch of freshly caught flies was fed first on an infected animal, and then fed on successive days on a series of healthy animals, using a fresh animal for each feed ; the experiments covering a period of 22 days from the time of the original infection of the flies. All such experiments, however, gave entirely negative results. On the other hand we obtained positive proof that *G. palpalis* can convey trypanosomes by means of its proboscis from an infected to a healthy animal, if it goes straight from one to the other. Our method of experimenting was as follows : A single fly was placed in a test-tube and the mouth of the tube covered with gauze. The mouth of the tube was then pressed on to the infected animal and the fly carefully watched. When the fly had about half fed it was removed from the infected animal and placed on a healthy one, on which it was allowed to finish its meal. Infection by trypanosomes was effected by this means in four out of five experiments when *G. palpalis* was used as the transmitting agent, and once out of four experiments when a Stomoxys was used in a similar manner. In order to determine further whether in these cases the infection was brought about by contamination with the fly's proboscis only or by the possible regurgitation of already ingested trypanosomes from the digestive tract, a further series of experiments was carried out, in which the fly, after having partially fed on an infected animal, was then allowed to feed on two healthy animals in succession. Five such experiments were carried out, in each of which it was observed that the fly (Glossina) had sucked blood from both the infected and the two healthy animals. In every case the *first* of the two healthy animals, and only the first, was infected, even when the fly had only been allowed to dip its proboscis for a moment into the first healthy animal and was then immediately transferred to the second healthy animal. This shows, in our opinion, that the infection is conveyed by contamination of the proboscis, and that if the fly be allowed to clean its proboscis by piercing the skin of one animal, it is no longer infectious to a second. In these experiments upon direct transmission the "Jinja" cattle-trypanosome was used by us, because it is abundant in the blood of infected animals (rats) with which we were working, and also on account of the fact that the infection or non-infection of a rat with this trypanosome is a matter of certainty within a very few days, whereas had we used *T. gambiense* the results of our experiments would have remained uncertain for a very long while.

It has also been proved by the experiments of Bruce and by ourselves that freshly caught specimens of *G. palpalis*, at Entebbe, are capable of infecting animals with the trypanosome of sleeping sickness, but in this case all experiments seem to show that the number of fly-bites required to produce infection is a very variable one indeed, since over and over again more than 1,000 flies have fed on a susceptible animal without infecting it. The smallest batch with which we ourselves have been successful in producing infection consisted of 134 flies.

Observations on the fate of trypanosomes, introduced into the digestive tract of the tsetse-fly by feeding it in the laboratory upon animals infected with *T. gambiense* gave the following results :—The trypanosomes, never very numerous in the ingested blood, show at the end of 24 hours a slight increase in number, and many of the parasites are observed in stages of division. At the same time they have become differentiated into two very distinct forms. The first is a very slender type with cytoplasm free from granules, with the nucleus sometimes rounded but more usually compressed, and with a considerable length of free flagellum (Plate 1, figs. 1 to 6). Many of these slender forms are observed at this stage to be in the act of extruding granules of chromatin from the nucleus (Plate 1, figs. 4 to 6). The second form of parasite is relatively very large and bulky with granular and deeply-staining cytoplasm, with very large spherical nucleus, with short free flagellum, and with the blepharoplast often some distance from the posterior end (Plate 1, figs. 7 to 14). These two forms may be regarded, on the analogy of developmental facts recorded of other trypanosomes, as male and female respectively. In both forms stages of division were observed, but in no case have we succeeded as yet in observing with certainty any process of conjugation. The two forms are easily distinguished in the living condition, the slender males being also characterised by much greater activity than the bulky females.

Male and female forms could also be recognised in the blood of the experimental animals (monkeys) especially in films fixed with osmic vapour. In films dried in the ordinary way, the characteristic differences were much less distinct. In either case the differentiation of sexual characters is far less marked than it becomes in the intestine of the fly. Trypanosomes of male character (Plate 1, fig. 16) are common in blood-films, but those of female character (Plate 1, fig. 17) are very scarce, and only two were found, both of which were remarkable for having the nucleus composed of four distinct masses of chromatin. On the other hand, an abundant form in the blood films is an indifferent type (Plate 1, figs. 18 and 19), characterised usually by very short free flagellum, and it is this form which develops into the female form in the fly. In this connection attention should be drawn to the forms, distinctly of the female type, obtained by two of us (Gray and Tulloch) in a culture (Plate 1, fig. 20, *see* Appendix II).

It may be pointed out that the sexual forms of *T. gambiense* from the tsetse-fly are very similar to the forms of *T. brucei* described by Koch* from other species of Glossina, so far as can be judged from Koch's figures. It is our opinion, however, that many of the forms described by Koch as developmental stages of *T. brucei* are really stages of one or more distinct aspects of trypanosomes carried by the flies, comparable to, and perhaps identical with, *T. grayi* and *T. tullochii* in *G. palpalis.*

At 48 hours after feeding the trypanosomes are still numerous in the intestine of the fly, and a type of more indifferent character begins to make its appearance (Plate 1, fig. 15). At 72 hours the trypanosomes are usually beginning to become more scanty and difficult to find in the digestive tract of the fly, although in some cases they are still numerous and chiefly of the indifferent type. At 96 hours, in almost every case, not a single trypanosome could be found even after the most careful searching. In one case a single trypanosome was found, and in another case two, on the fourth day, but in all other cases the trypanosomes seemed to have vanished completely at this period, and could never be found at any subsequent time. It would appear as if they died out with the absorption of the blood with which they were ingested, and were unable to pass forward in the digestive tract into the blood taken up by the fly at any subsequent feeding. In this they contrast sharply with the trypanosomes described above, occurring in the fly under natural conditions.

The disappearance of *T. gambiense* from the digestive tract of the tsetse-fly could be interpreted in one of three ways : (1) the trypanosomes may actually die out and be digested ; (2) the trypanosomes may pass from the digestive tract into other organs of the fly ; (3) the trypanosomes may become, by rapid division, so minute as to escape detection, like the forms of *Spirochæta ziemanni* described by Schaudinn, or like the invisible micro-organism of yellow fever. In order to test the second of these two possibilities, the internal organs of a number of artificially infected flies were carefully examined, but always with negative results, while the experimental results of Bruce and ourselves seem to disprove infectivity of the fly at any period after 48 hours, and, therefore, render improbable the third possibility suggested above. So far then as it is possible to draw conclusions from our observations, it would appear that *T. gambiense* does actually die out in the tsetse-fly after the third day. In all cases *T. gambiense* was found only in the mid-gut of the fly, and appeared never to pass either backwards into the proctodæum or forwards into the proventriculus, another point in which they contrast with the "fresh fly trypanosomes."

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* "Deutsch. Med. Wochenschr.," 1905, No. 47.

(B) *Observations and Experiments upon Freshly-caught Tsetse-flies Found to Contain Trypanosomes.*—When freshly-caught tsetse-flies were examined by us in the laboratory, either after having been fed upon a healthy animal or not, a certain percentage of them were found to contain trypanosomes of one or rarely of both types referred to above as *T. grayi* and *T. tullochii*. In such cases the trypanosomes were usually present in enormous numbers, especially if the fly had been previously fed. These trypanosomes, when compared with *T. gambiense* artificially introduced into a fly's intestine, are distinguishable by their appearance and movements. They are far more active than the sluggish *gambiense*, especially the male forms, which often shoot across the field of the microscope with the greatest rapidity. When moving in this way the body of the parasite remains nearly stiff, while the forwardly directed flagellum vibrates with rapid serpentine movements. In a few cases they were found in masses in the proctodæum, but in most cases they occurred in the intestine, swarming and multiplying in the freshly ingested blood. Occasionally they were found passing along the thoracic intestine into the proventriculus. The parasites found in the proventriculus did not differ appreciably either in size or appearance from those found in the digestive tract. By the method suggested by Koch, of compressing the bulb of the proboscis, we succeeded in forcing trypanosomes out from the proboscis, but only in those flies in which the parasites were found in the proventriculus. Of the two types described above *T. grayi* was the most commonly found, being present in 1·47 per cent. of a total of 3,000 flies examined, while *T. tullochii* was found in 0·17 per cent. of flies, and both trypanosomes together in the same fly only three times. When trypanosomes were found in the fly's proventriculus, it was more usually *T. tullochii* which was present, while when trypanosomes were found only in the fly's intestine, it was more usually *T. grayi* that occurred, but no conclusions can be drawn from this until more flies have been examined.

The object of our experiments on these "fresh fly trypanosomes" was to determine whether one or both of the two types found were or were not developmental stages of *T. gambiense*. As it is now beyond all doubt that *G. palpalis* is the agent which conveys the trypanosome of sleeping sickness from an infected to a healthy individual, it would seem most probable at first sight that any trypanosomes found in the bodies of these tsetse-flies caught in a sleeping sickness area would be developmental stages of *T. gambiense*. We felt no doubt at the outset of our investigations that these fresh fly trypanosomes were to be identified with *T. gambiense*. Koch* evidently worked on the same assumption, since in his comparison of the supposed developmental stages of *T. brucei* and *T. gambiense* there can be no doubt that he has taken the form which has been called *T. grayi* for a developmental phase of *T. gambiense*. As we proceeded, however, with our investigations we were gradually led to doubt any connection between these "fresh fly trypanosomes" and sleeping sickness. In order to determine this point we carried out a number of experiments on flies caught on the island of Kimmi. This island was chosen because it swarmed with these tsetse-flies, of which a high percentage contained trypanosomes, and because it was, and has been for a very long while, quite uninhabited.

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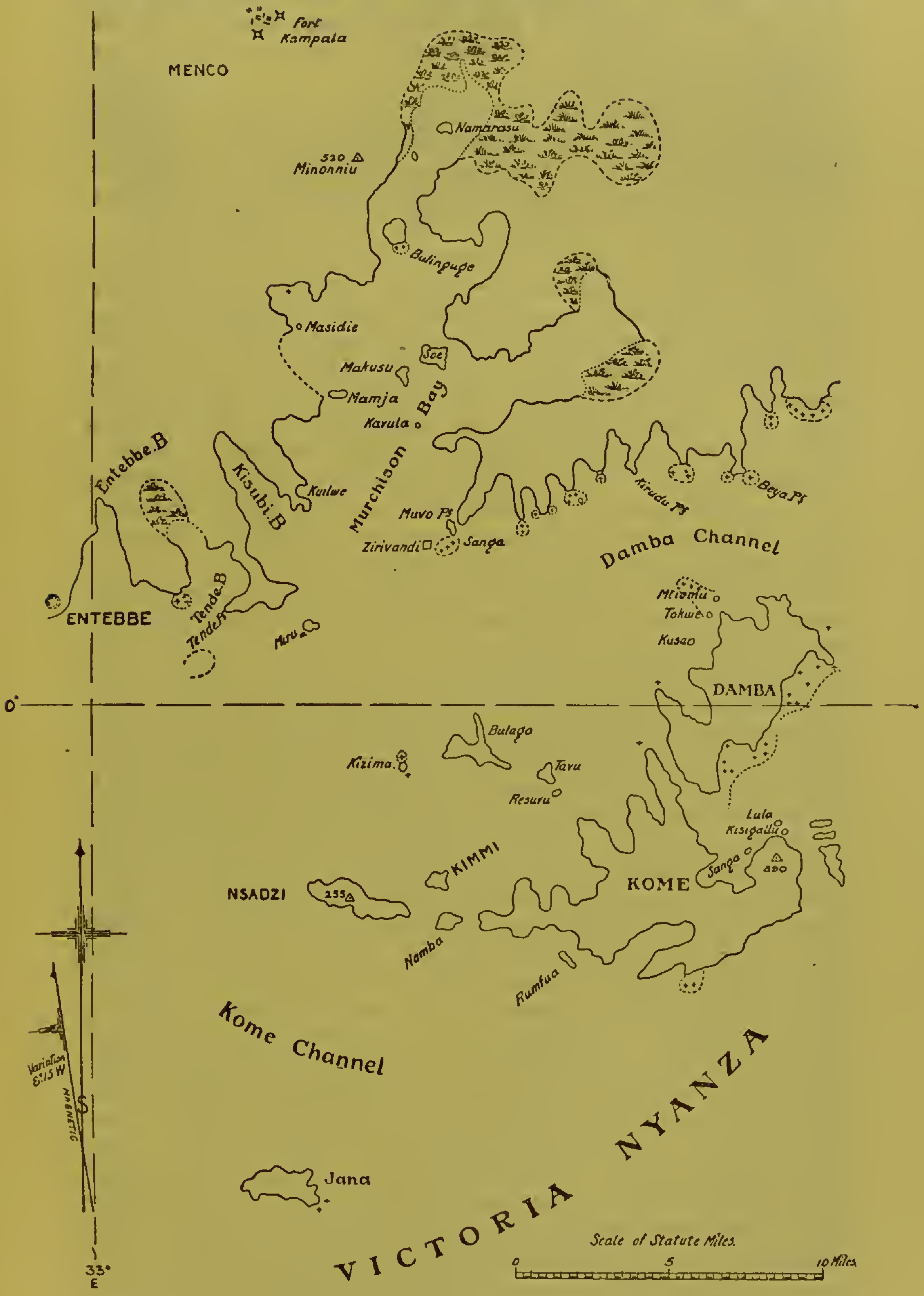
* "S. B. k. pr. Akad. Wiss. Berlin," 1905, pp. 958–262.

Kimmi is a small island of the Sesse group, about two miles long by a mile wide (*see* map). There is a narrow strip of sandy shore all round it, the remainder of the island being covered with thick undergrowth and forest. On the foreshore are many ambatch trees, where cormorants, other diving birds, and weaver birds are very plentiful. This island is a regular feeding ground for hippopotami and is crossed in all directions by their tracks. Crocodiles are also very numerous. Kimmi is situated about 15 miles from Entebbe and is two miles from Nsadzi Island in the one direction and from Kome Island in the other. For more than a year this island has been quite uninhabited and natives now never visit it. The whole island swarms with tsetse-fly (*G. palpalis*). In spite of the total absence of human beings on Kimmi Island, we found that more than 7 per cent. of the tsetse-flies caught there contained trypanosomes of one or other of the two types mentioned, while only 1·7 per cent. of the flies caught on the main land near Entebbe, a place with a numerous population, among whom sleeping sickness is common, contained similar parasites.

Our method of experimenting with these flies was as follows:—Our camp with our apparatus and experimental animals, was placed on the neighbouring healthy Island of Nsadzi, in a region free from fly and where there is no sleeping sickness. A steam-launch was placed at our disposal by the authorities and by means of it batches of flies were brought back from Kimmi, so that we were not obliged to take possibly infected native canoemen, a class among whom sleeping sickness is very common, to this island. These Kimmi flies were divided into batches and each batch assigned to a particular animal (monkey, rat, guinea-pig, or hen) on which the batch was fed at once, and again repeatedly on successive days. After 12 days or a fortnight of such daily feeding, the flies of each batch were dissected and examined for the trypanosomes which they might contain. In practically every case one or more flies of each batch were found to contain trypanosomes, so that every experimental animal was definitely known to have been fed upon repeatedly by at least one fly containing trypanosomes. Had these trypanosomes therefore been identical with *T. gambiense*, it might have been expected that at least some of these susceptible animals (such as monkeys, guinea-pigs, and rats) would have become infected, *but this did not occur in a single instance.* We thought that *T. grayi* might possibly be a bird-trypanosome, but the negative results of feeding flies containing it on fowls did not bear out this supposition.

PART OF THE SESSE ISLANDS



In addition to these feeding experiments, we inoculated other experimental animals of the same kinds with the contents of the various parts of the digestive tracts of flies containing these trypanosomes, some from the proventriculus, some from the intestine and some from the proctodæum, *but again in every case the results were negative.*

We are, therefore, now convinced from the results of these numerous experiments, of which a list is given on p. , *that the trypanosomes found in the freshly-caught tsetse-flies, and referred to by us as* T. grayi *and* T. tullochii, *have nothing to do with sleeping sickness and are not developmental stages of* T. gambiense.

It is a matter of regret to us that we have not been able to establish on what vertebrate host, if any, these trypanosomes are parasitic. It seemed at least probable that *T. grayi*, some forms of which greatly resemble *T. johnstonii*, Dutton and Todd* from *Estrelda estrelda*, was taken up by the fly from some of the numerous water birds that haunt the lake-shore. On the other hand, *T. tullochii*, which is very similar in its morphological characters to *T. gambiense*, might similarly be derived from a mammalian host. We may draw attention in this connection to the remarkable manner in which this tsetse-fly haunts the lake-shore. There is nothing in the breeding habits of the fly which should oblige it to frequent the vicinity of water, as in the case of the mosquito. Our experience of flies kept in the laboratory convinced us that a certain amount of moisture is necessary for them, since they died much faster in their cages if not kept over water. It may be supposed, however, that one attraction that the lake-shore exerts upon this voracious blood-sucker, is that of food-supply. Along the shores of the lake and on all the small islands are vast numbers of cormorants and other fish-eating birds perched with their wings extended, drying themselves in the sun on the trees, and especially on the ambatch-trees, where the flies are found in swarms. These birds might furnish one constant and important source of food. We found in the laboratory that tsetse-flies fed very rapidly on captive fowls, creeping under their wings to bite the poorly protected parts of the skin. On the other hand, when a heap of recently shot water-birds, some of which were hardly dead, were lying on the lake-shore at Kimmi Island, the swarms of tsetse-flies did not attempt to settle on them, although freely biting us and our servants. A second possible source of food supply is furnished by the aquatic animals of the lake shore, such as the hippopotamus, the otter, the crocodile and the python. We have definite evidence that the fly feeds on the hippopotamus and on the crocodile. Flies were caught in the act of biting a hippopotamus just recently shot, settling chiefly on the ears and nose. We, therefore, made blood-films and had blood-films sent us of as many aquatic birds and animals as possible, including five or six hippopotami. Only in a single case did we find a trypanosome, namely, in a not very well preserved film of crocodile's blood ; beyond its large size and general resemblance to other reptilian trypanosomes, it was not possible to make out any details of structure in this parasite. We may mention, however, that the blood of many of the birds contained Halteridia, and that a Hæmogregarine was quite common in the blood of the crocodiles (fig. 1). We also observed that flies in captivity sucked the blood of lizards, chameleons and snakes very freely.

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* Liverpool School of Tropical Medicine, *Mem.* XI. Pl. 2, fig. 1.

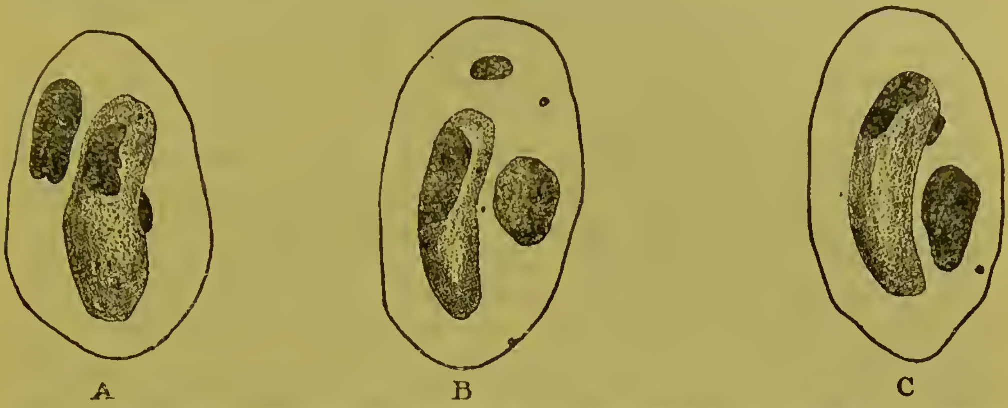


FIG. 1.—Hæmogregarine in the red blood-corpuscles of the crocodile. × 2000.

There are, therefore, two possible sources for the trypanosomes in the freshly-caught tsetse-flies. Either they are taken up from some of the numerous animals upon which the fly feeds, or they may be parasites of the fly itself, like *Herpetomonas muscæ-domesticæ* in the house-fly. In this respect it is interesting to note that a small percentage of another common blood-sucking fly in Uganda (Stomoxys sp.) contain a species of Herpotomonas very similar to that of the common house-fly in Europe. With regard to *G. palpalis* we were never able to obtain any definite proof that it fed on anything but blood. It is therefore difficult to understand how a parasite of the tsetse-fly itself could be conveyed from one fly to another except by the hereditary method. We have a single instance to record which certainly suggests hereditary transmission of these trypanosomes. A tsetse-fly was bred in the laboratory in August and was fed for two months on fowls, which were unfortunately also used for feeding our stock of tsetse-flies in our breeding cages. On October 9, the fly was fed on a monkey showing very scanty trypanosomes (*T. gambiense*) in its blood. The next day 21 hours later, this fly was dissected and found to contain a few scanty *T. gambiense*, one of which is figured on Plate 1, fig. 14, and vast swarms of *T. grayi* (Plate 2, figs. 23 and 28). It is obvious, therefore, that this fly was either infected with *T. grayi* when it emerged from its pupa or that it became infected from one of the fowls which had possibly been infected in its turn by the fresh flies which fed on it. It may be mentioned in this connection that experiments directed towards obtaining flies infected with *T. gambiense* by the hereditary method, that is to say, by breeding from flies fed continually on infected animals, gave no result.

In conclusion, one remarkable experiment of ours may be mentioned. At our camp on Nsadzi, referred to above, we fed a large number of freshly-caught Kimmi flies on a goat which we obtained from natives on the island. We then dissected these flies and, to our astonishment, could not find trypanosomes in a single one of some 500 flies which had so fed, whereas in other Kimmi flies, caught at the same time, which had fed on our other experimental animals (monkeys, etc.), trypanosomes were present in the usual proportion. We then prepared some goat's serum and added a drop of it to the contents of a fly's intestine teased out on a slide, which contained *T. grayi* in large numbers. Another drop of this same goat's serum was added to a preparation of *T. gambiense* obtained from an infected rat and the two preparations watched. It was found that in the preparation of *T. grayi*, the trypanosomes rapidly became immobile and died off, while the *T. gambiense* remained active. We then tried the same two experiments over again, using human serum instead of the goat's serum, and then found that the trypanosomes were not affected in either case. This result seems to us to furnish an additional means of distinguishing between *T. gambiense* and *T. grayi*.

APPENDIX I

Table I.—List of Animals on which Tsetse-flies known to contain Trypanosomes of the two types mentioned have fed. All these animals remained uninfected by this feeding.

Animal.	Number of flies which had fed found to contain trypanosomes.	Class of trypanosome present in fly.	Presence or absence of trypanesomes from fly's proventriculus.
Monkey No. 370 ...	2	*T. grayi.*	
” No. 391 ...	3	”	
” No. 369 ...	2	”	
” No. 397 ...	1	”	Present.
” No. 335 ...	3	*T. grayi* in two flies. *T. tullochii* in one fly.	Present in one of the former.
” No. 474 ...	2	*T. grayi* in one and *T. tullochii* in the other.	Present in both.
” No. 499 ...	4	*T. grayi.*	Absent in all.
” No. 525 ...	5	”	”
” No. 553 ...	1	”	Absent.
” No. 554 ...	4	”	Present in one fly.
” No. 473 ...	2	*T. grayi* in one and *T. tullochii* in the other.	Present in both.
” No. 498 ...	4	*T. grayi.*	Absent in all.
” No. 555 ...	1	”	Absent.
” No. 556 ...	3	”	Present in two.
” No. 557 ...	1	*T. grayi* and *T. tullochii* together.	Present.
Guinea-pig, F. F. ...	8	*T. grayi* in 7. *T. tullochii* in 1.	Present in two.
” No. 528 ...	5	*T. grayi.*	Absent.
Rat (white). No. 533 ...	1	*T. tullochii.*	Present.
Hen No. 505	4	*T. grayi.*	Present in two.
Hen No. 506	6	*T. grayi* in 5. *T. tullochii* in 1.	Present in three.

APPENDIX II.—*An Experiment on the Cultivation of* T. gambiense.

By Lieutenant A. C. H. GRAY, R.A.M.C., and the late Lieutenant F. M. G. TULLOCH, R.A.M.C. (Sleeping Sickness Commission).

Our numerous failures in this direction have been attended by one partial success.

The following method was employed. A tube of agar, prepared according to the formula of McNeal and Novy, was melted and cooled to 60° C. Three times its volume of blood, taken directly from the heart of a dog without defibrination, was added to the agar. The water of condensation was inoculated with a drop of blood from a white rat (No. 513) very rich in trypanosomes. On examining the tube six days later a few living trypanosomes were found, which appeared similar to the forms inoculated. On the 8th and 10th days no trypanosomes were seen in a loopful of fluid withdrawn from the tube. On the 15th day several active trypanosomes were seen in a sample. These trypanosomes were found singly and in groups of three or four. Dividing forms were also seen. These forms were distinctly larger than the trypanosomes originally inoculated, and on measurement were found in some cases to be as long as 54 μ. Besides being longer and broader than the trypanosomes in the blood of the rat the position of the micro-nucleus was different (Plate 1, fig. 20). In the trypanosomes from the test-tube the micro-nucleus was situated at a considerable distance from the hinder end of the parasite and consequently nearer to the macro-nucleus. These trypanosomes closely resembled certain forms which we have found in the stomach and intestinal tract of tsetse-flies, 24 hours after being allowed to feed on infected monkeys. On the 17th day trypansomes were still present in about the same numbers but a few cocci were also found in the tube. Up to the 20th day trypanosomes were still found, but were sluggish in their movements and became fewer in number as the cocci increased. After this date the growth of cocci became profuse and the trypanosomes died off. Up to the present (seven days) no trypanosomes have been found in sub-cultures made from this tube although the latter are free from bacteria.

As multiplication had commenced in the original tube it is reasonable to expect that a successful culture would soon have resulted if it had not become contaminated by cocci.

The resemblance of the newly-formed trypanosomes to forms seen in tsetse-flies after feeding on infected animals is of interest.

APPENDIX III.—*Some Notes on a* Herpetomonas *found in the Alimentary Tract of* Stomoxys (*calcitrans*?) *in Uganda.*

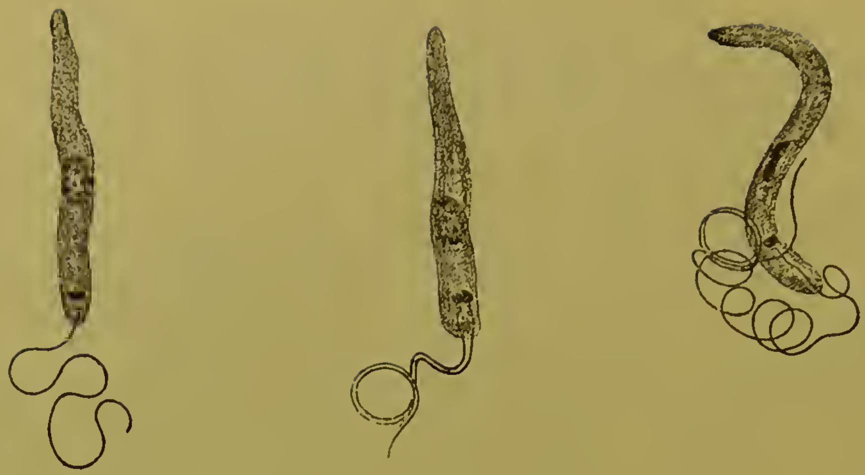
By Lieutenant A. C. H. GRAY, M.B., R.A.M.C.

In the course of examining the contents of the alimentary tract of some specimens of Stomoxys (*calcitrans*?), which had previously been allowed to feed themselves on a monkey infected with the trypanosome of sleeping sickness, I found a species of Herpetomonas in the alimentary tract of three flies out of a total number of 280 examined.

In its movements, size, and general appearance, the flagellate seemed to closely resemble *H. muscæ-domesticæ* of the common house-fly.

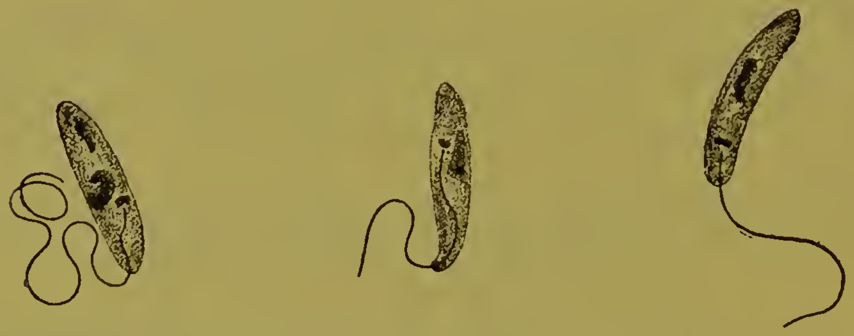
In two flies, this parasite was present in very large numbers. Those two flies were full of blood from the monkey they had fed on 24 hours previously, and in this blood, practically unaltered *T. gambiense* were present in scanty numbers. In the third fly, this Herpetomonas was present in very scanty numbers and no trace of recently ingested blood could be found in it.

Films, fixed in osmic acid and stained with Borrel blue and eosin, showed that the commonest type of this parasite measures from 35 to 50 μ (figs. 1, 2, 3).



FIGS. 2–4.—Herpetomonas from the gut of Stomoxys (*calcitrans?*); fig. 2, common form with single flagellum, and with nucleus broken up into separate masses; fig. 3, commonest form, with double flagellum; fig. 4, form with compressed nucleus and very long flagellum.

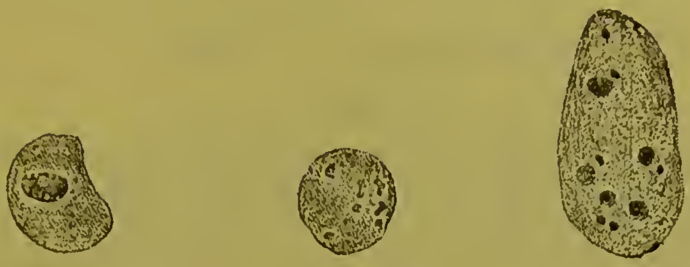
The body of the parasite is cylindrical, with a rounded anterior and more pointed posterior extremity. The protoplasm of the body stains rather deeply. A large rounded nucleus is placed at the centre of the body of the parasite. The chromatic substance of the nucleus is sometimes seen to be broken up into granules (chromosomes), apparently 14 in number, contrasting in this respect with *H. muscæ-domesticæ*, in the nucleus of which eight chromosomes are present (Prowazek). The blepharoplast is oval or kidney shaped, of a large size and stains deeply. It is placed close to the origin of the flagella and to the anterior rounded extremity of the body of the parasite. The double flagellum arises close to the blepharoplast and may reach an enormous length in some individuals (fig. 3).



FIGS. 5–7.—Herpetomonas from gut of Stomoxys; fig. 5, small form with dividing nucleus; fig. 6, small form showing the posterior position of the blepharoplast, and long intracellular course of the flagellum; fig. 7, small form, ordinary type.

Besides these large forms, smaller individuals are present (figs. 4, 5, 6). The bodies of these parasites stain more faintly than the above and are often curved. The nucleus is more compressed. The blepharoplast is smaller and situated at a greater distance from the anterior extremity of the body. The single flagellum arises close to the blepharoplast and consequently has a somewhat longer course through the body of the parasite. It emerges as a short, thick, free flagellum.

Both these forms commonly undergo longitudinal division. In some cases the nucleus apparently divides before the blepharoplast.



FIGS. 8-10.—Herpetomonas from gut of Stomoxys, non-flagellated forms; fig. 8, mass of blue-staining protoplasm containing one large chromatin body; figs. 9 and 10, masses of protoplasm containing paired chromatin bodies.

In the third fly non-flagellated forms were found to occur (figs. 7, 8). Masses of blue-staining protoplasm containing chromatin bodies in pairs (fig. 9) were also rarely found in this fly. Every such pair of chromatin bodies consisted of a larger and a smaller separate portion. The larger portion is circular and more faintly staining, the smaller is oval and more deeply staining. These paired masses of chromatin suggest a form analogous to Leishman-bodies.

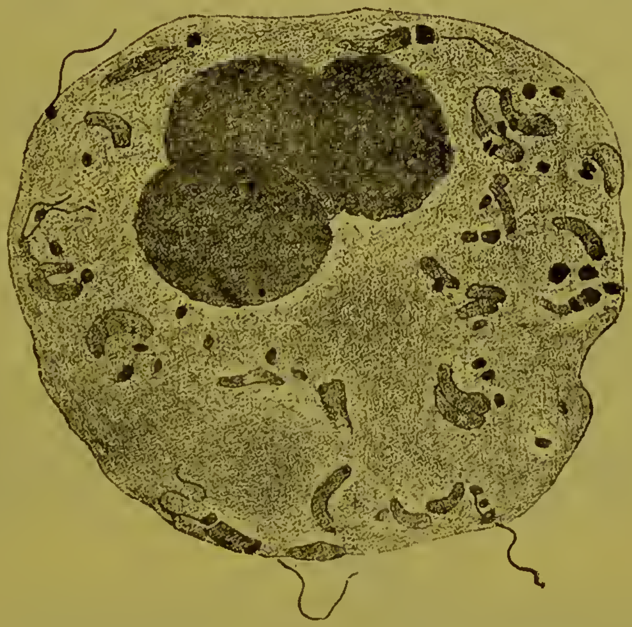


FIG. 11.—Large cell (probably a leucocyte) from contents of gut of Stomoxys (*calcitrans?*), containing in its interior large numbers of disintegrated Herpetomonas forms.

On several occasions, in the first two flies, large cells (leucocytes?) were found containing in their interior the broken-up remains of large numbers of the Herpetomonas (fig. 10).

The figures illustrating these notes are all × 2000 and drawn with the camera lucida from slides fixed in osmic acid and stained with Borrel blue and eosin.

DESCRIPTION OF PLATES.

PLATE 1.

Trypanosoma gambiense, figs. 1–14, forms from the gut of the tsetse-fly (*Glossina palpalis*) one day after infection (*i.e.* about 24 hours) after being taken up by the fly. Fig. 15, two days (48 hours) in the fly. Figs. 16–19, forms from the blood of a monkey (*Cercopithecus* sp.) infected with the injection of cerebro-spinal fluid from a sleeping sickness patient. Fig. 20, culture form from blood of infected rat, 15th day. All except figs. 14 and 20 preserved wet with osmic vapour stain, Leishman or Geimsa. × 2000.

Figs. 1 and 2, male form with compressed nucleus. Fig. 3, male form with rounded nucleus. Figs. 4 and 5, similar forms with chromatin being given off from the nucleus Fig. 6, male form dividing chromatin being given off from both the daughter nuclei. Figs. 7–14, female forms, figs. 7 and 12 dividing. Fig. 15, indifferent form. Fig. 16, male form. Fig. 17, female form, very scarce (only one other was found). Figs. 18 and 19, indifferent forms which in the fly become female; note the short, free flagellum. Fig. 20, female form from culture tube, 15th day.

PLATE 2.

Trypanosoma grayi, figs. 21–30, from the gut of the tsetse-fly (*Glossina palpalis*). The flies from which these trypanosomes were obtained had been fed regularly on the blood of neutral monkeys and were dissected after about 10 days of such feeding: In all cases the whole gut of the fly swarmed with thousands of similar trypanosomes. Figs. 31 and 32, small forms; flies dissected 24 hours after their first feed of blood generally contained forms such as these in very great abundance, many dividing forms were also present, larger forms, as above, were rare. Figs. 33–35, trypanosomes from fresh-caught tsetse flies, which had not fed on blood for a long while. In such flies, parasites were never very numerous, and the types present were all of a large size. Figs. 36–40, various other types from flies which had fed on blood. Fixed in alcohol, stained with Leishman or Giemsa. × 2000.

Figs. 21 and 22, male forms with compressed nucleus and long free flagellum. Figs. 23, 24 and 25, female forms. Posterior extremity thickened, short free flagellum. Figs. 26, 27 and 28, stages of division showing the unequal size of the two resulting individuals. Fig. 29, division of a small form into two more or less equal-sized individuals. Fig. 30, aberrant dividing form, in this case the nucleus has already divided, whereas the blepharoplast has not yet done so. Figs. 31 and 32, young forms resulting from the unequal division of a large female form. Fig. 33, very long male form. Fig. 34, very large female form. These two forms occur in flies which have not fed on blood for a long time. Fig. 35, very long form, with nucleus consisting of eight chromosomes. Figs. 36–40 are all from the same fly. Figs. 36, 37, and 38 show the nucleus broken up into separate chromatic granules, and the varying position of the blepharoplast. Fig. 39, young form showing regular division of the nucleus into eight chromosomes. Fig. 40, young form showing a separate mass of chromatin posterior to the nucleus.

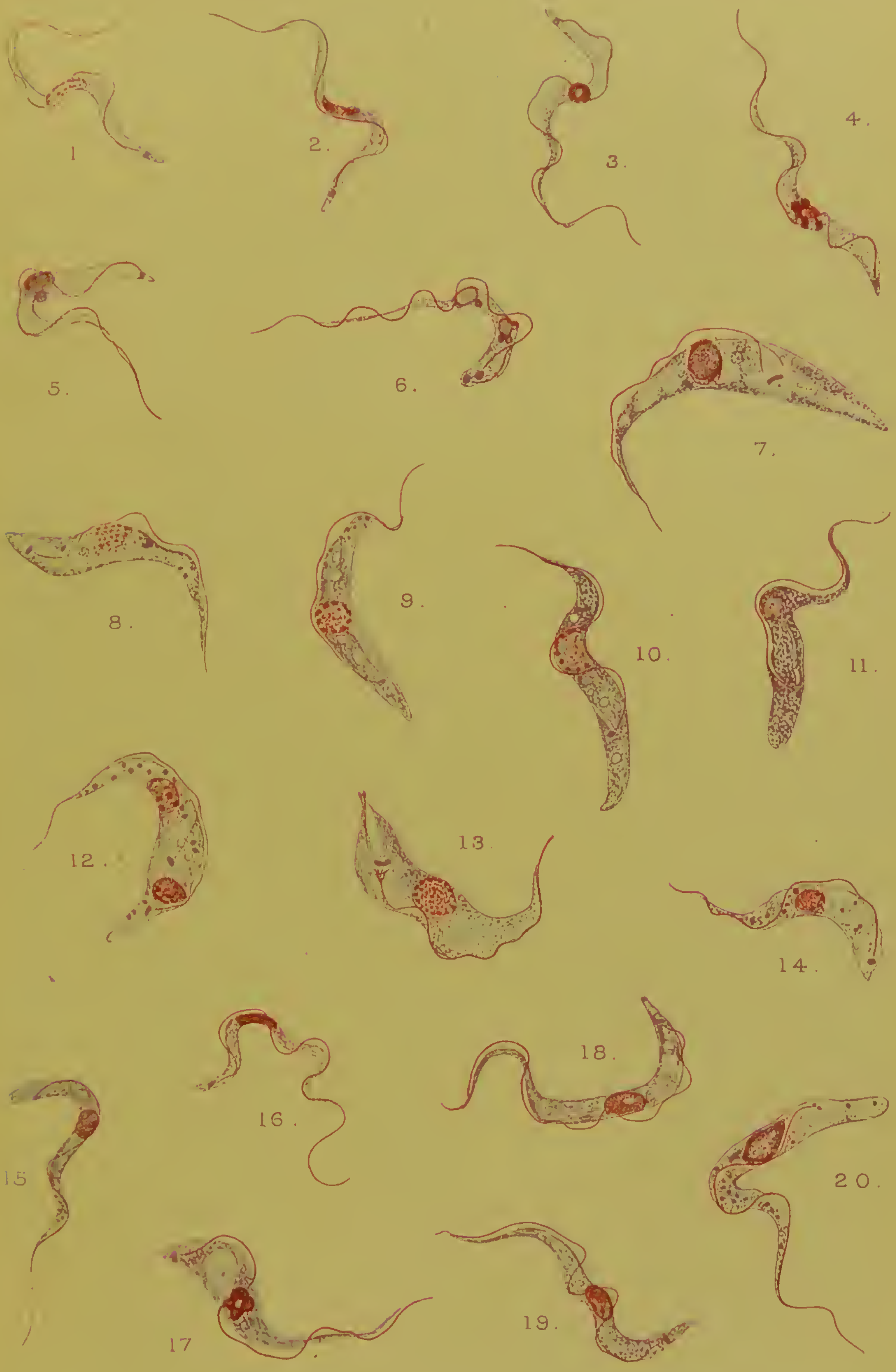
PLATE 3.

Trypanosoma grayi, figs. 41–52; *Trypanosoma tullochii*, figs. 53–60; all from the gut of the tsetse fly (*Glossina palpalis*). Fig. 41, very large female form, undergoing unequal division from a fly which had not fed on blood. Fig. 42, rosette-like mass of similar young forms. Figs. 43–51 are all taken from the same fly, and show the various steps in the formation of circular non-flagellated forms from a common type. Fig. 43. Figs. 44 and 45 show the flagellum becoming wrapped round the body of the parasite. Figs. 46, 47 and 48 show progressive stages in the absorption of the flagellum. Figs. 49, 50 and 51 are different types of the resulting non-flagellated bodies. Fig. 52, an uncommon type of parasite, with very large blepharoplast, and showing much chromatic granulation, from a fly which had not fed on blood.

Figs. 53–60, *Trypanosoma tullochii*. Fig. 53, small form, with minute circular blepharoplast and small vacuole. Fig. 54, larger form of a similar type. Fig. 55, small form showing the flagellum arising from a small granule of chromatin close to the blepharoplast. Fig. 56, large form. Figs. 57 and 58, large forms of trypanosome found in the proventriculus of an infected fly. Fig. 59, dividing form, common type. Fig. 60, dividing form, rare type showing division into three. Figs 53–60 are all from the same fly. Figs. 57 and 58 are from the proventriculus, while the remainder are from the gut of the fly (*Glossina palpalis*).

Minchin Gray & Tulloch

Sleeping Sickness, Report VIII, Pl. I



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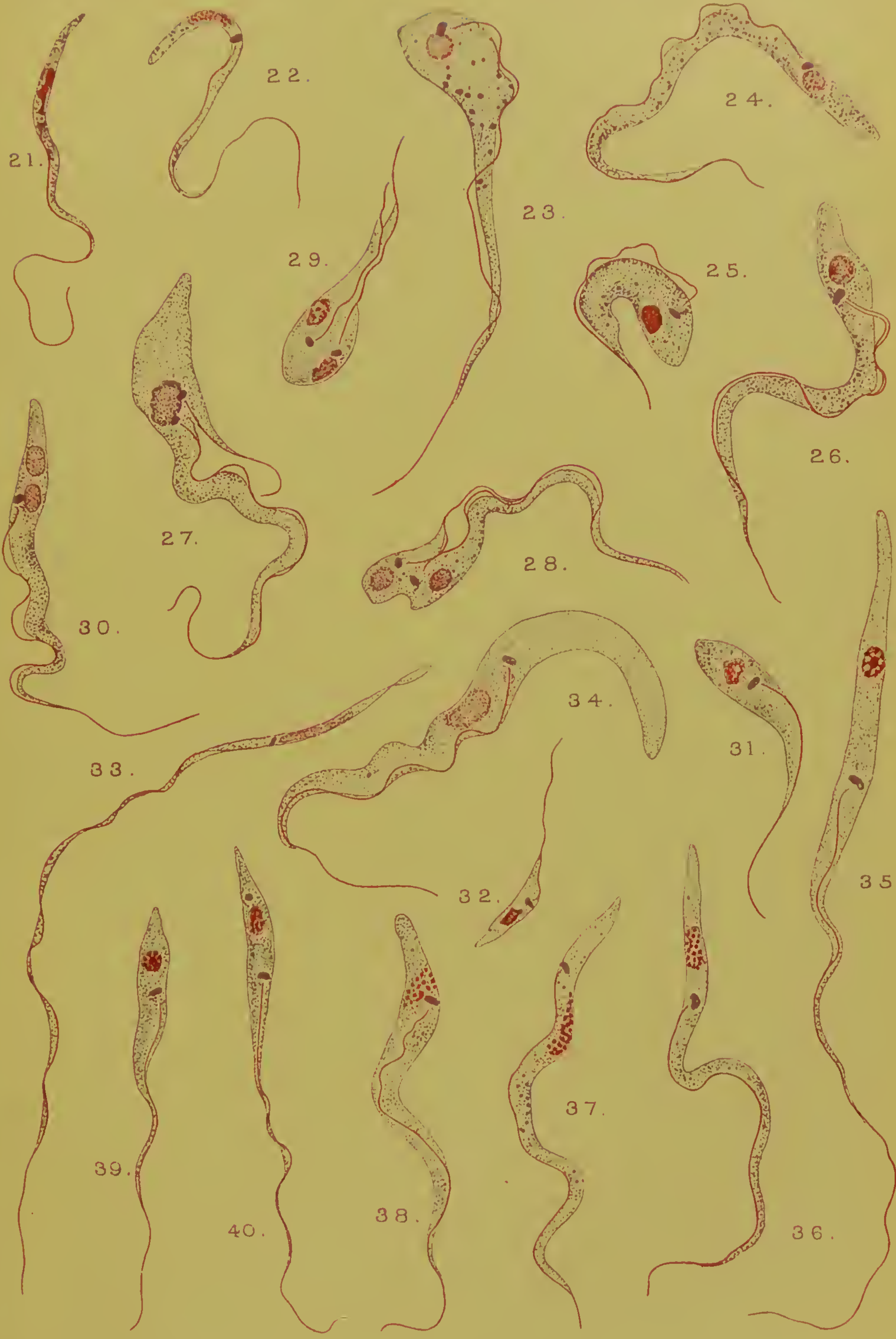
TRYPANOSOMA GAMBIENSE × 2000.



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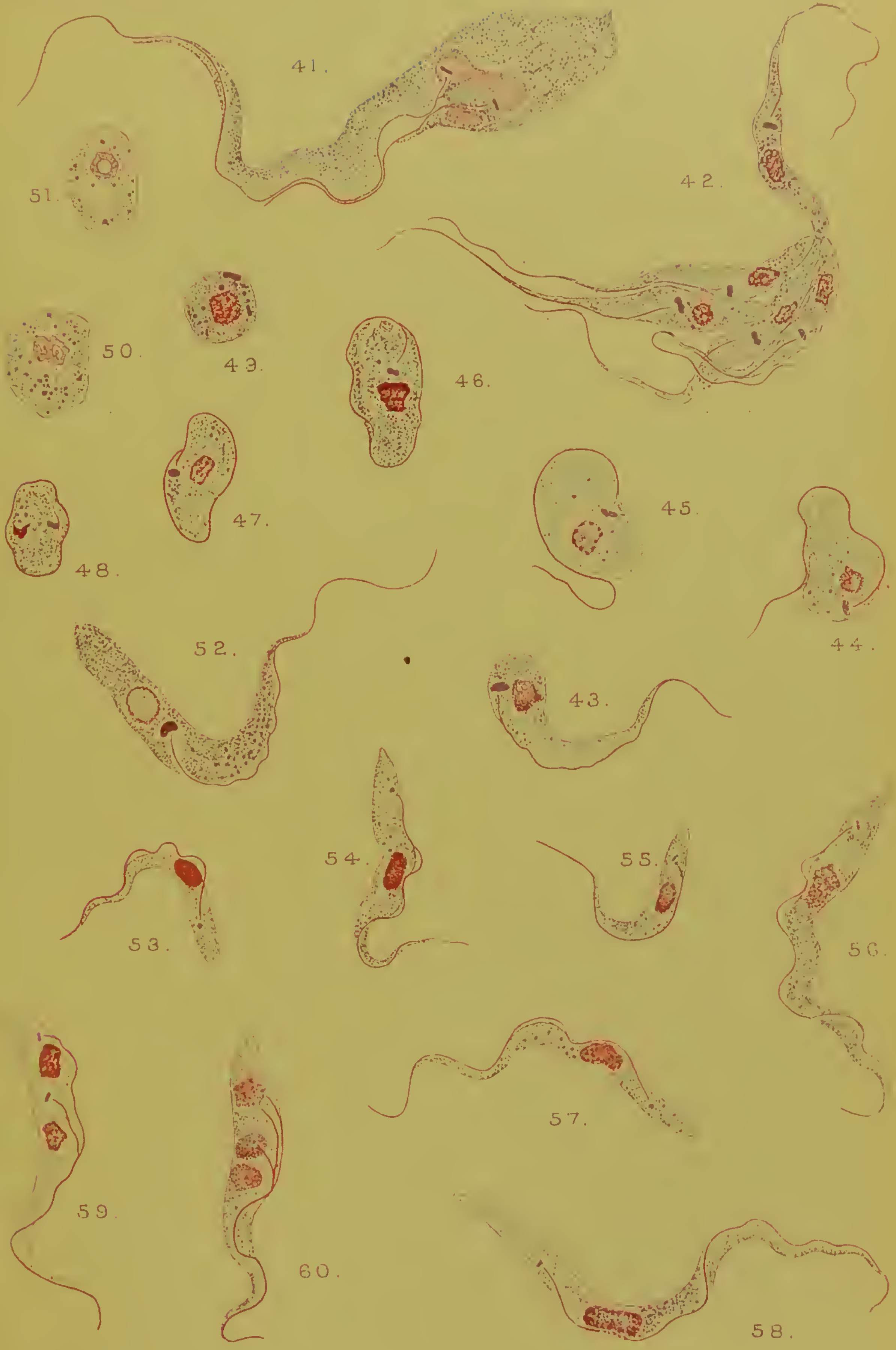
TRYPANOSOMA GRAYI × 2000.



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TRYPANOSOMA GRAYI AND T. TULLOCHII × 2000

22. ON THE OCCURRENCE OF ENCYSTATION IN *TRYPANOSOMA GRAYI* NOVY, WITH REMARKS ON THE METHOD OF INFECTION IN TRYPANOSOMES GENERALLY.

By E. A. Minchin, M.A.

[*Reprinted from* Proceedings of the Royal Society, Series B, Vol. 79.]

In a tsetse-fly dissected and examined by me in the laboratory of the Sleeping Sickness Commission at Entebbe, Uganda, it was found that not only was the intestine swarming with *Trypanosoma grayi*, but the proctodæum also contained vast numbers of trypanosomes. Under moderate magnification they could be seen in dense clumps attached to the wall of the proctodæum, each clump having a superficial resemblance to a patch of mould, the whole mass, however, vibrating with the movements of the flagella. It was rather uncommon to find these parasites in the hind gut, and I at once made smears from different regions of the digestive tract, and carefully preserved and stained them. As it was but a short time before my departure from Entebbe, I was not able there to do more than glance at my preparations, but I noticed at once an important fact which, since my return to England, I have been able to confirm and extend by careful study of my slides: namely, that in the hind-gut the trypanosomes are in process of becoming encysted. Before proceeding to describe the encystment, I will say a few words about the conditions of the occurrence of these trypanosomes, and the manner in which they were preserved.

The tsetse-fly in question was one of a batch caught by our fly-boys at Entebbe on November 2, and fed the next day on a monkey infected with *Trypanosoma gambiense* from the cerebro-spinal fluid of a sleeping sickness patient. On every subsequent day these flies were fed on a healthy guinea-pig, and a certain number of flies were dissected daily and examined, until the batch was used up. Without going into details it is sufficient to say that *T. gambiense* was found sparingly in the flies dissected up to 96 hours, that is to say, on November 4, 6, and 7. After this date *T. gambiense* disappeared completely and could not be found in any of the flies dissected. The fly in which the encystment was discovered was dissected on November 14. It must, of course, have been infected with *T. grayi* when caught, and, as I have stated, it had been kept 11 days in the laboratory and fed daily. At the autopsy it was found to be gorged with blood, and with all its organs perfectly normal and healthy in appearance. I examined the salivary glands and genital organs (tsetses and vesiculæ seminales) without finding anything resembling a trypanosome. Finally the digestive tract was examined with the results stated. No trypanosomes were found in the proventriculus.

The films were made in the usual way by drying the smears, which were then fixed with methyl alcohol and stained with Giemsa's stain. A few were kept unfixed and have been fixed and stained for me recently by my assistant, Dr. J. D. Thomson, with excellent results. It is a matter of great regret to me now that none of my smears of this fly were fixed by the osmic-vapour-method. The method of drying smears is a drastic one, which is likely to deform finer details, and in the present instance the cyst-wall is often injured, being evidently of a soft consistence.

The gut was divided into four regions and smears made from each. In the anterior region of the intestine the ingested blood is of red colour, very thick, and jelly-like and difficult to smear out nicely. Further back it gets more fluid and begins to turn black. In the hinder part of the intestine the blood is black and fluid. I refer to these three regions briefly as the red, red-black, and black blood respectively. The black blood stops sharply and suddenly at the point at which the Malpighian tubules enter the gut. The proctodæum contains no blood, but only a yellowish fluid containing innumerable coarse granules.

I proceed now to describe briefly the process of encystation observed by me in the fly. A glance at the preparation shows many different stages of the process side by side. In the first place we find individuals in which encystment has not begun (figs. 1, 2). These are forms for the most part very slender and smaller than any of the forms of *T. grayi* found in the intestine of this or other tsetse-flies ; but their most striking feature is the absence of any distinct undulating membrane, so that they bear a great resemblance to the genera *Herpetomonas* and *Crithidia*, especially the latter. The flagellum is long and appears to run down the side af the body. The blepharoplast has the large size and rod-like form characteristic of *T. grayi*. The nucleus is either compact or broken up into granules of chromatin. Division stages have been found, but are very rare.

In the first stages of encystment the flagellum becomes shortened and stains more deeply, suggesting that as it diminishes in length it becomes thickened. At the same time the cyst begins to appear as a layer of substance which stains reddish with Giemsa, forming a cap at the hinder pole (figs. 3, 4,). These two processes continue until on the one hand the flagellum is completely retracted and on the other hand the body is enveloped in a pear-shaped cyst, at first incomplete towards the pointed end (figs. 5, 6). The flagellum appears to become retracted into a pink-staining vacuole (fig. 5, *fl. v.*), which reminds one of the flagellar vacuole described by Leishman during the formation of a flagellum in the Leishman-Donovan bodies in cultures, but here the sequence of events is inverted, as it were. Finally the pink vacuole disappears, but a streak, which gradually fades away, can be seen for a time in front of the blepharoplast (fig. 6). The cyst closes up round the pointed end of the body, and then changes in form, becoming first oval (fig. 7) and then irregularly circular in outline (fig. 8). In the circular cysts, which are the last stage, it is difficult to make out much detail, but in favourable examples they can be seen to contain hyaline protoplasm, staining faintly bluish, with the dark purple-stained blepharoplast and the nucleus generally represented by irregularly scattered granules, staining a purplish-red tint. The cyst-wall also stains strongly and appears slightly redder than the nucleus.

I will now state briefly the conditions observed in other parts of the gut of the fly in which the cysts were found. The red blood was found teeming with trypanosomes, nearly all large forms of indifferent type. Very few young forms were found, and male forms were very scarce. No pronounced female types were found in this region, though many of the large indifferent forms approach the female type in the shortness of their free flagellum. In the red-black blood the conditions were similar, but young forms are becoming commoner. In the black blood young forms predominate and large individuals are comparatively infrequent. Thus in the gut of this fly as a whole we find great rarity of differentiated sexual forms, but a swarm of indifferent forms which in the hinder part of the intestine give rise to very numerous young forms, and these in their turn would appear to pass into the small, *Herpetomonas*-like forms found in the proctodæum, starved-looking creatures which, in a medium where there is probably no nutriment, go through the process of encystment already described.

Having so far confined myself strictly to matters of fact, I will now offer a few suggestions and speculations as to the probable significance of the encystation in the economy of the life-cycle of the parasite. In the first place, the resemblance of these cysts, and especially the pear-shaped forms, to the "Schleim-cysten" decribed by Prowazek* in *Herpetomonas muscæ-domesticæ* Burnett, is very marked, and has struck everyone to whom I have shown both my preparations and Prowazek's figure. I think there can be no doubt that they are similar bodies, and have a similar function, that is to say, that they are destined to pass out of the gut of the fly with its dejecta. Very numerous analogies in support of this inference could be cited from other parasitic Protozoa. The question which interests us most is, what becomes of them after being cast out from the fly? In the absence of any observations or experiments upon this point, one can only draw conclusions from the analogy of what is known in other cases. In the case of *H. muscæ-domesticæ*, the cysts are scattered about everywhere, and as house-flies are far from being particular in their feeding or sanitary in their habits, a fly runs every chance of infecting itself with the *Herpetomonas* by swallowing with its food cysts dropped by another fly. There can be no doubt whatever, it seems to me, that this is the manner in which the house-fly acquires the infection of the *Herpetomonas*. The case is, however, very different with the tsetse-fly, which does not haunt the enclosed spaces and insanitary surroundings of the house-fly, but lives a free, open-air life by lake and forest. Nor is the tsetse-fly a foul feeder like the house-fly. My assistant, Mr. Degen, and myself made many attempts to feed tsetse-flies on all kinds of food, but always without the least success. On the other hand, the tsetse-fly is a greedy blood-sucker, and will attack anything from a frog, lizard, or bird to a hippopotamus, but, in my opinion, it does not feed in any other way. Further, the tsetse-fly is not like the *Stomoxys*, which lays its eggs in dung; it is viviparous, as is well known, and nourishes its larva in the uterus until full-grown.

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* "Arbeiten a. d. k. Gesundheitsamte," Berlin, vol. 20 (1904), p. 446.

For all these reasons, it seems to me in the highest degree improbable, indeed, I may say impossible, that a tsetse-fly would ever infect itself by sucking up cysts dropped by another fly, or that a parasite which had to depend on this method of dissemination could maintain its existence in the tsetse-fly. The only possible destiny I can imagine for these cysts is to be swallowed accidentally by some vertibrate, the (as yet unknown) host of *Trypanosoma grayi*, in order to germinate in its digestive tract, to pass thence into the blood, and to be taken up again with the blood by the tsetse-fly. A cycle of this type is as yet unknown, but there are abundant analogies for all parts of it. In the first place, it is a common thing for animals to have protozoan parasites in the gut, which they take up in the encysted condition after they have been dropped by another individual. Without multiplying instances unnecessarily, I may point out that Schaudinn proved the infection of *Amœba coli* to originate in this way, and that it is a common human parasite in regions where sanitation has not advanced beyond the primitive condition of *épandage par terre*. In the second place, there are many instances among Sporozoa of cysts germinating in the intestine and liberating motile forms which then pass through the wall of the gut into other organs of the body.

In a former communication by my colleagues,* Lieutenants Gray and Tulloch, and myself, we were able to confirm Bruce's results as to the existence of direct mechanical infection by means of the tsetse-fly, which if it stabs its proboscis first into an infected animal and then soon after into a healthy one, can infect the latter. We were not able to demonstrate, however, what I may term cyclical infection, which at present has not been shown to exist. I suggest that there are two possible modes of cyclical infection, in the dissemination of protozoan blood-parasites by biting insects generally. In one method, which I may term *inoculative*, the parasite, after going through developmental changes in the insect, passes back again into a second vertebrate host through the proboscis, as in the case of malaria transmitted by a mosquito. In the other method, which I propose to term *contaminative*, the parasite taken up by the biting insect, after going through developmental changes within its gut, would pass

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* "Roy. Soc. Proc.," vol. 78 (1906), p. 242.

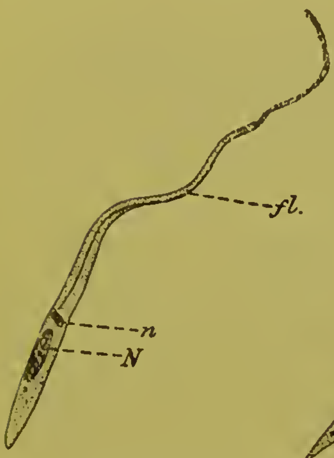


Fig. 1.

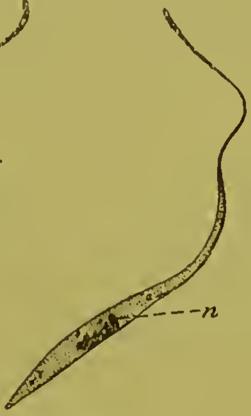


Fig. 2.

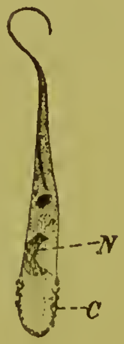
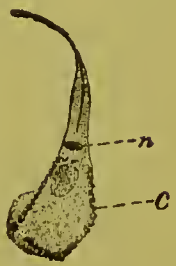


Fig. 3.



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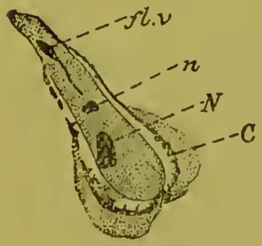

Fig. 5.

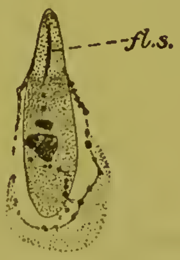

Fig. 6.

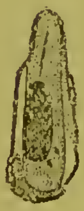

Fig. 7.

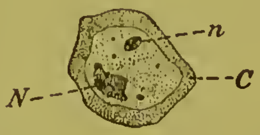

Fig. 8.

DESCRIPTION OF THE FIGURES.

Figs. 1 and 2.—Free-swimming *Herpetomonas*-like forms of *Trypanosoma grayi* from the proctodæum of the tsetse-fly, before encystation has commenced ; *N.*, principal nucleus ; *n.*, blepharoplast ; *fl.*, flagellum. × 2,000.

Fig. 3.—Commencement of encystation. The flagellum is becoming retracted, and the first appearance of the cyst-secretion is seen at *C.* × 2,000.

Fig. 4.—Similar stage slightly more advanced. The cyst-wall (*C*) is damaged at one point. × 2,000.

Fig. 5.—Flagellum completely retracted, represented by a vacuole (*fl. vac.*). × 2,000.

Fig. 6.—The flagellar vacuole is absorbed and the flagellum is represented only by a delicate streak (*fl. s.*). Cyst much damaged. × 2,000.

Fig. 7.—The cyst-secretion now extends all round the body. × 2,000.

Fig. 8.—Rounded-off cyst, the final stage. Letters as before. × 2,000.

out of it through the anus, and infect the vertebrate host by contaminating its food or drink. We have all of us (I speak for myself) been imbued hitherto with the idea that the cycle of the trypanosome in the tsetse-fly must be of the inoculative type and have failed to find it. I wish to suggest strongly to those working on the subject of trypanosome-infection the desirability of making experiments and observations to prove or disprove the existence, in the insect which disseminates the parasite, of a life-cycle which results in a contaminative infection of the vertebrate host.

A full account of the trypanosome-cysts described in this note, and of other points relating to *Trypanosoma grayi*, will be published, with illustrations, in the "Quarterly Journal of Microscopical Science."